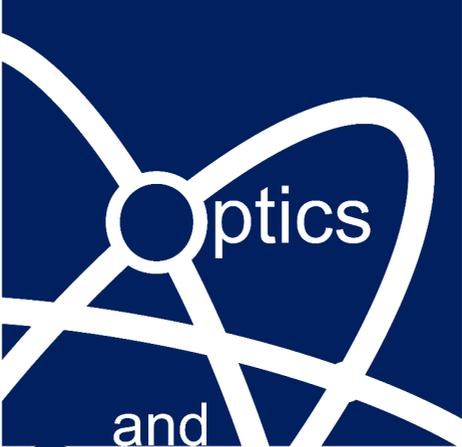


DEVELOPMENTS in

and
Communications
2019

Book of Abstracts



Riga, Latvia, April 11 – 12 , 2019

15th International Young Scientist conference

Developments in Optics and Communications 2019

Book of Abstracts

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Welcome

The Organizing Committee kindly welcomes you to the 15th International Young Scientist conference “Developments in Optics and Communications 2019”. This conference is organized jointly by University of Latvia SPIE student chapter and OSA Latvian student chapter. The purpose of this conference is to bring together students and young scientists working experimentally and theoretically in the fields of optics and photonics to share and exchange new ideas and to establish contacts for future collaboration. The conference traditionally covers the following topics:

- Laser Physics and Spectroscopy;
- Biophotonics;
- Optical Materials and Phenomena;
- Vision Science.

The organizers wish you a fruitful conference and a pleasant and memorable stay in the capital of Latvia!

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Program

Thursday, April 11 University of Latvia, House of Science, Room 401	
8:00 - 9:00	Registration
9:00 - 9:30	Opening session
9:30 - 12:00	BIOPHOTONICS Chair: Mindaugas Tamosiunas
9:30 - 10:30	Invited: Stefan Andersson-Engels Development of monitoring of infant lung function based on NIR infrared spectroscopy of oxygen gas and water vapour
10:30 - 10:45	Anastasija Caica Thermal imaging for assessment of septic shock patients
10:45 - 11:00	Alise Aglinska Imaging photoplethysmography for assessment of cutaneous sensory nerve ending function
11:00 - 11:15	Margarita Matulenko The impact of laser diodes light beam homogeneity on the quality of the phantom chromophore mapping images
11:15 - 12:00	Invited: Dmitrijs Bliznuks Non-contact skin cancer diagnostic system: Results and challenges running cloud based diagnostics
12:00 - 13:00	Lunch break
13:00 - 14:45	OPTICAL MATERIALS AND PHENOMENA Chair: Aigars Atvars
13:00 - 13:45	Invited: Arturs Bundulis Asymmetrical all-organic waveguide gas sensor
13:45 - 14:00	Daina Damberga 1D ZnO/PDA nanostructures: deposition and characterization
14:00 - 14:15	Arturs Smiltnieks Detection of magnetic thin film impurity phases using nitrogen vacancy centers in diamond crystal
14:15 - 14:30	Julija Pervenecka Investigation of photoluminescence and reduction of amplified spontaneous emission threshold value of cyanoacetic acid derivative in PVK matrix
14:30 - 14:45	Guna Doke Short-wave infra-red long persistent luminescence of MgGeO ₃ :Yb ³⁺ material
14:45 - 15:00	Short break
15:00 - 15:45	Invited: Tatjana Pladere Soft skills training: Capturing audience attention
15:45 - 16:45	Poster session: Biophotonics + Optical materials and phenomena
16:45 - 17:00	Meeting for City Rally on the first floor
17:00 - ...	City Rally in Old Riga

Friday, April 12

University of Latvia, House of Science, Room 401

9:00 - 12:00	VISION SCIENCE Chair: Sergejs Fomins
9:00 - 10:00	Invited: Antonio M. Morgado Imaging the eye: structure, function and window to the body
10:00 - 10:15	Sanita Liduma The impact of keratoconus apex's localization on eye aberrations
10:15 - 10:30	Zane Jansone Development of a comparative eye structure table
10:30 - 10:45	Short break
10:45 - 11:00	Viktorija Malugina Topographical changes of the cornea after sleeping in soft contact lenses
11:00 - 11:15	Renars Truksa Colour ensembles
11:15 - 11:30	Megija Bambane Form and color perception in children
11:30 - 12:00	Invited: Resident Doctor in Ophthalmology Kristine Fomina Presentation of Latvian American Eye Center (LAAC)
12:00 - 13:00	Lunch break
13:00 - 15:15	LASER PHYSICS AND SPECTROSCOPY Chair: Laima Busaite
13:00 - 14:00	Invited: Aigars Atvars
14:00 - 14:15	Darya Menailava Ab initio multi-reference perturbation theory studies on the LiRb and KCs molecules and transport properties of some alkali metals media
14:15 - 14:30	Patricija Paulsone Optical properties and amplified spontaneous emission of new synthesised glass forming pyranilyden derivatives
14:30 - 14:45	Kristians Draguns Modelling of sensors based on whispering gallery mode optical microresonators
14:45 - 15:00	Balys Momgaudis Experimental assessment of absorbed pulse energy via time resolved digital holography
15:00 - 15:15	Anastasiya Martynava Determination of chemical composition of micrometeorites by laser-induced breakdown spectroscopy
15:15 - 15:30	Short break
15:30 - 16:30	Poster session: Vision science + Laser physics and spectroscopy
16:30 - 17:30	Closing session and award ceremony
17:30 - ...	International evening party with organizers

Biophotonics: invited speakers

Development of monitoring of infant lung function based on NIR infrared spectroscopy of oxygen gas and water vapour

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Preterm infants suffer often from poor lung function as the organ may not be fully developed. Many complications can arise from poor lung functions including risks for morbidity and even mortality. Today infants at risk are treated in intensive care units with frequent X-rays taken to control the lungs. We are assessing the possibilities to use non-invasive NIR spectroscopy to measure the amount and concentrations of oxygen in the alveoli in the lungs. Hopefully a transdermal probe can be developed to facilitate better monitoring tools, potentially improving the care of these fragile patients at risk.

Non-contact Skin Cancer Diagnostic System: Results and Challenges Running Cloud Based Diagnostics

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During the past two years, a team of multidisciplinary scientists developed a scalable cloud-based skin cancer diagnostic system[1]. The accuracy of the analysis is comparable to the one made by a dermatologist[2]. Total number of tested lesions is reaching 2000. During the development and implementation stages, numerous improvements were made to the diagnostic algorithm and systems' software and hardware modules. Most important and interesting aspects will be presented here.

The motivation for creating such an automatic diagnostic system was a wish to bring fast skin cancer analysis to the broader public. According to the statistics, malignant melanoma is the deadliest type of skin cancer, however, the possibility to cure is extremely high at the early stages of the disease[3]. Developed system is designed to be used at the general family doctors, where the majority of patients could be tested. Otherwise, patients with melanoma would go to the dermatologist only when lesion is obviously suspicious and it could be too late for treatment.

The diagnostic system is comprised of multiple handheld imaging devices and a cloud-based diagnostic system. Handheld devices use multi-spectral cross-polarized diffuse reflectance in three spectral bands (526 nm, 663 nm and 964 nm) and autofluorescence analysis under 405nm LED continuous excitation with 520nm cut filter[4]. The skin images are wirelessly transferred to the cloud for immediate analysis. This design allows scientists to bring their newly developed diagnostic algorithms to the live system almost instantly, without special adoption for specific architecture. All modules of the system were made for easy distribution and scalability. Therefore, the system is not just a laboratory equipment, but a ready to use system for non-experienced users.

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Acknowledgements

This work has been supported by European Regional Development Fund project 'Portable Device for Non-Contact Early Diagnostics of Skin Cancer' under grant agreement 1.1.1.1/16/A/197.

Biophotonics: student talks and posters

Imaging Photoplethysmography for assessment of cutaneous sensory nerve ending function

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Introduction. Accumulated evidence suggests that skin perfusion can reflect different chronic diseases and due to its accessibility may serve in diagnostics. Particularly important problem is assessment of cutaneous nerve ending functions which is still challenging due to the lack of non-invasive objective diagnostics. Imaging photoplethysmography is a simple and non-intrusive technique for blood pulsation detection and can be used in assessment of cutaneous functions[1]. Well known cutaneous response is neurogenic flare to topical skin heating, mediated by an axon reflex involving sensory nerve fibers. The aim of present pilot study was to explore capability of imaging photoplethysmography for assessment of cutaneous sensory nerve ending function by means of topical skin heating flare test[2].

Methods. Study comprised 11 healthy volunteers. The thermostatic heating probe has placed on the subject dorsal aspect of palm and heated (20 min at 43 C). After probe removal heated skin region was illuminated by 540 nm light and video recorded with monochromatic camera. The iPPG perfusion index map was computed offline from video signal[2].

Results. The PPG perfusion map demonstrated substantially increased perfusion in heated skin region in comparison to intact, indicating on axon reflex produced extensive vasodilation and flair (see.Fig1.). The group mean relative flare index was $43 \pm 12\%$. It has been concluded that imaging photoplethysmography might be used for assessment of cutaneous nerve ending function using topical heating flair test which traditionally is performed by laser Doppler imaging technique. .

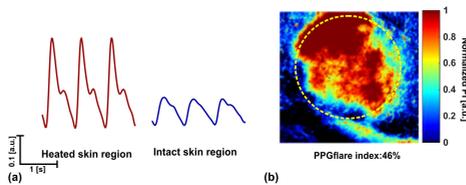


Figure 1: Heated and intact skin . iPPG Waveforms (a), iPPG perfusion index map (b).

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Thermal imaging for assessment of septic shock patients

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Introduction. Severe sepsis and septic shock are major infectious causes of mortality of critically ill patients worldwide with a high incidence (1.8 million cases annually). In the case of sepsis, an uncontrolled inflammatory cascade affects the microcirculation throughout the body deranging its regulation and causing vital organ failure which may progress in hours therefore rapid assessment of patient health state is challenging [1]. The promising non-invasive contact-less technique for indirect microcirculation monitoring is thermography[2]. However there are no studies confirming its application in assessment of septic patients. In the present pilot study the capability of thermal imaging was explored in assessment of septic shock patients.

Methods. Ten septic shock patients admitted to intensive care unit were selected. The thermal data was acquired from patients left and right thighs with FLIR A655sc camera. After segmentation the thermal image was assign to one of the five degrees based on the amount and the nature of so called hot spots- increased temperature skin regions. In this scale 0 degree represented no hotspots and in 5th almost 90% of thigh area was covered by hotspots (see Fig.1.). The relationship between patient survival and hot spot degree was assessed.

Results. The preliminary data exhibited tendency for positive correlation between hotspot degree and patient survival, indicating on potential of thermal imaging as a bedside method for assessment of septic shock patients. However to reveal this relationship more extensive study on larger patient group is required.

Acknowledgements. This work was supported by the European Regional Development Fund project No. 1.1.1.1/16/A/065 Optical Non-invasive Hybrid Method for Early Diagnostics and Therapy Guidance in Sepsis.

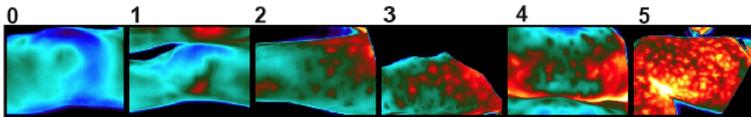


Figure 1: Figure1.Representative example of hot-spots scale: 0 degree to 5 th degree

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The impact of laser diodes light beam homogeneity on the quality of the phantom chromophore mapping images

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Different optical devices with special laser illumination are used worldwide. For example, in medicine they are used for diagnosis, treatments and therapies. Therefore, it is very important to be convinced that the device is reliable. Laser diodes of different spectral lines might unevenly distribute the light, thus affecting the result of chromophore mapping [1]. The aim of the work was to test laser diodes light beam homogeneity during phantom chromophore mapping with three and four laserline illumination devices, and to develop new phantom-based light field homogeneity test.

Two different laser diode beam scattering mechanisms and the homogeneity of illumination are compared in this work. In first case, six laser diodes – two for each wavelength (448nm, 532nm, 659nm) – were arranged in a cylinder and their beams were pointed to 45-deg conical reflecting edge of a transparent disc; beams' reflections were turned radially towards the internal ring-shaped flat milky-Plexiglas diffuser, and afterwards a skin phantom was illuminated. In second case, four different wavelength (405nm, 457nm, 532nm, 659nm) laser diodes were used. Laser beams were focused on a diffuser and reflector which vibrated to reduce laser speckle effect. Agar-based skin phantoms with different chromophore concentrations were used as test subjects. The phantoms consisted of three layers, imitating the three main layers of the human skin: epidermis, dermis and hypodermis [2].

The results showed how the uneven dispersion of laser beams affects the accuracy of chromophore mapping and what scattering mechanisms give better results.

This work was supported by the project *Advanced spectral imaging technology for skin diagnostics* Izp-2018/2-0006

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Optical Materials and Phenomena: invited speakers

Asymmetrical all-organic waveguide gas sensor

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Technologies regarding gas sensing is rapidly developing due to necessity of miniaturized, low-cost sensors for industrial safety systems, food quality checking and medical diagnostics. As waveguide photonic devices have proven to be applicable for different measurement technologies, more and more research has been carried out regarding their implementation for gas sensing. Main advantages of optical waveguide sensors are they are immune to electromagnetic interference, cheap to produce and are small.

To detect chemical changes in environment we can employ devices that changes refractive index due to adsorption onto or absorption into material. This can lead to resonance shifts in devices such as whispering gallery mode resonators, hetero-core and waveguide Mach-Zehnder interferometric devices. In all of the previously mentioned examples the sensitivity is determined not only by the device design, but also on the employed materials. In this work we present an all-organic waveguide device for volatile solvent detecting. Device consists of SU-8 waveguide core and cladding material consisting of mixture from Poly(methyl methacrylate) and novel organic material 2-(4-(bis(5,5,5-triphenylpentyl)amino)benzylidene)-1H-indene-1,3(2H)-dione (DMABI-Ph6). Main advantages of this device are low production cost, wide spectral bandwidth in the visible spectral range and high sensitivity. Device was tested using isopropanol, acetone, acetonitrile, dimethylformamide and water in mixture with N₂ vapor. The sensing mechanism is enabled by cladding absorbing solvent vapor thus changing its refractive index.

Device sensitivity as well as switching time was measured for all of the selected gas mixtures. Device stability under prolonged exposure to vapor was studied. Additionally device was tested before and after heating it over the cladding glass transition temperature to understand how the free-volume of the cladding influences sensitivity of the device.

Optical Materials and Phenomena: student talks and posters

Photoconversion efficiency in solar cells based on heterostructures ITO-Si with Au nanoparticles

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Nowadays, solar energy is considered as a promising tool for solving the global energy crisis. Among the technologies aimed at increasing the efficiency of solar cells, two main directions are presented: tandem solar cells and solar cells based on heterojunctions [1,2]. However, often the actual values of the efficiency of such solar cells are much smaller than the theoretical limit. The deposition of nanoparticles of noble metals, e.g. Au, on the surface of solar cells is a promising method for increasing light absorption in the spatial charge due to the excitation of surface plasmons in metallic nanoparticles [3,4].

The aim of our work is to find out the influence of nanostructured Au film on the efficiency of photoconversion and the lifetime of nonequilibrium charge carriers in solar cells based on ITO-Si heterostructures. Our samples were grown by the magnetic sputter deposition method in vacuum. The surface of ITO was covered with a thin layer of Au. To create Au nanoparticles with diameters of 5, 10 or 20 nm the annealing at 300°C was used. The shape of nanoparticles was controlled by means of atomic-force microscope Integra (NT-MDT) with Si tip with radius of 10 nm.

We investigated the spectral dependences of optical absorption of Au-ITO films and photoconductivity of Au-ITO-Si heterostructures and also the kinetics of photovoltage relaxation after photoexcitation with light pulses. Spectral and time dependences of photovoltage were studied at temperatures in the range 80-290 K.

We observed that covering the surface of ITO with a layer of Au nanoparticles leads to increasing of the photovoltage amplitude due to increasing of the potential barrier height in the system. Excitation of the surface plasmons leads to increasing of the efficiency coefficient due to the effects of local amplification.

The short-circuit current of solar cells has been reduced after the deposition of Au films due to the absorption and reflection of a part of the light with Au films. However, in some heterostructures, the optical losses in the Au film were compensated by the effect of plasmon amplification, which determined its highest efficiency.

Also, the deposition of a nanostructured Au film leads to increasing of the lifetime of nonequilibrium charge carriers compared to the initial structure of ITO due to the creation of electrostatic potential variations in the near-surface Si region. At the same time, the effects of plasmon amplification do not affect the observed relaxation times of photovoltage.

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Detection of magnetic thin film impurity phases using nitrogen vacancy centers in diamond crystal

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Negatively charged nitrogen-vacancy centers in diamond are a well established [1] platform for nanoscale resolution, high sensitivity room-temperature sensors capable of many detection modulates such as magnetometry, electrometry, thermometry, gyroscopy and piezometry. NV centers are recognized magnetometric imaging tool for thin films[2,3]. The used method is based on optically detectable magnetic resonances (ODMR). By observing supplied microwave frequency and its dependence of fluorescence lights intensity we can construct map of magnetic field. In this work we demonstrate the detected magnetic impurity phases and their correlation with optically detected impurities and mechanical defects for different thin films (see Fig.1)

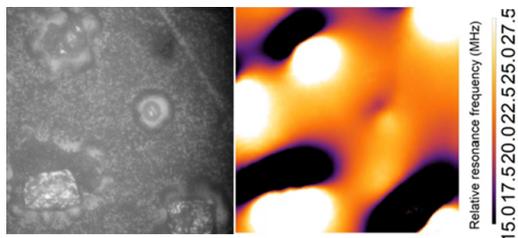


Figure 1: On the left side - optical image of a magnetic thin film with grain type impurities; on the right - corresponding areas magnetic field image with colour code scale that describes the relative ODMR frequency. Field of view is $30 \times 30 \mu\text{m}$

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Development of novel 1D ZnO/Polydopamine core shell nanostructures with advanced structure, electronic, optical and sensitive properties

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Forming of novel functional nanomaterials, such as organic shell/inorganic core with advanced structure, electronic and optical properties is important for different applications, such as sensors, antibacterial coatings, energy production etc. Polydopamine (PDA) is a novel biocompatible polymer with a number of functional groups. It can be used as layer for immobilization of biomolecules or reduction/oxidation reactions. ZnO is well known material with high room temperature photoluminescence, which can be used as optical sensor template. Forming of ZnO/PDA nanostructures can result in new photoinduced effects, related to photoluminescence and photocurrent. The present work demonstrates recent achievements in fabrication and characterization of 1D ZnO/PDA nanostructures. 1D ZnO nanowires were deposited by hydrothermal growth. Conformal coating of PDA was formed by chemical bath deposition and confirmed by EELS method (Figure 1.). Optical and electronic properties of 1D ZnO/PDA nanocomposites are investigated by use of XRD, Raman, TEM, SEM, optical and photoluminescence spectroscopy. Correlation between structural and optical properties of 1D ZnO/PDA nanostructures was performed. Mechanisms of observed photoinduced effects are discussed.

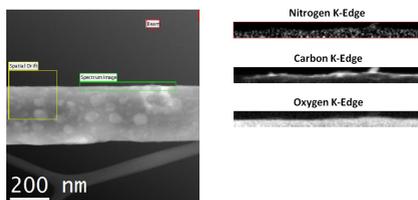


Figure 1: Electron energy loss spectroscopy (EELS) analysis for 3 hour chemical bath deposition of polydopamine with concentration 0.1mg/ml on ZnO

Acknowledgements: 1D ZnO/Polydopamine kodola aulas nanostruktru izstrde ar uzlabotu jutbu un uzlabotm strukturas, elektroniskajm un optiskajm pabm, within Latvian LZP fund (Reg. N. LZP 2018/1-0394) and the project Investigation of photoinduced processes in one dimensional ZnO/polydopamine nanostructures, within Latvian Post-doc program (Reg. N. ESS2018/295).

Generation of singlet oxygen during sonodynamic therapy *in vitro*
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Sensitizers derived from chlorophyll have been widely applied both for photodynamic and sonodynamic treatment of cancer. Generation of singlet oxygen is a primary mechanism of photodynamic therapy (PDT) however its involvement in sonodynamic therapy (SDT) still remains in dispute. This study tested whether singlet oxygen is generated during sonodynamic reaction *in vitro* when sensitized cells are exposed to ultrasound (US) instead of light.

Human malignant melanoma Me45 cells were prepared in 150 μ l of electroporation medium (10^6 cells/ml), incubated with sensitizer chlorin e_6 (Frontier Sci., USA) at 17 μ M final concentration for PDT group (or 170 μ M for SDT group) and irradiated subsequently. SDT was performed by 0.3 MPa acoustic peak negative pressure (PNP) US, generated by 6 mm diameter transducer (Sonitron 2000, Richmar, USA) operating at 1 MHz frequency, continuous wave and 60 s exposure. For PDT, cells were irradiated with 1 J/cm² light dose using 633 nm red laser (Altechna, Lithuania) at 20 mW/cm² fluence rate. These specific experimental conditions resulted in ~50% cell kill both in SDT and PDT groups. The control cells in US and light irradiated groups were prepared without chlorin e_6 administration. Additionally, all cells in SDT and PDT groups were added with singlet oxygen sensor green – SOSG (Promega Corp., USA) at 5 μ M final concentration prepared under manufacturer recommendations. The elevation of fluorescence at 531 nm is yielded by formation of SOSG endoperoxides and is considered an indication of singlet oxygen. Intracellular accumulation of SOSG was detected in SDT and PDT groups by using BD Accuri C6 flow cytometer (BD Biosciences, USA). Me45 cell supernatant spectral characteristics (decay distribution, intensity and spectra) were tested by using spectrofluorimetry (AvaSpec ULS2048L, Avantes, Netherlands; 473 nm excitation coupled to Y-shaped fiber bundle FC-UV400-2-SR). The cytotoxic effects of chlorin e_6 mediated SDT and PDT were evaluated by MTT assay.

Our study showed that singlet oxygen generation is a primary mechanism of chlorin e_6 mediated photodynamic therapy. Singlet oxygen was easily produced by photodynamic reaction *in vitro*, resulting in elevated intracellular and extracellular SOSG fluorescence levels as Me45 cell viability decreased by 50%. However, SOSG fluorescence was one order of magnitude lower under identical 50% cytotoxicity level induced by SDT. Therefore our study shows that singlet oxygen does not play a primary role in SDT induced Me45 cell damage observed in presence of chlorin e_6 .

This work has been supported by European Regional Development Fund project “Time-resolved autofluorescence methodology for non-invasive skin cancer diagnostics” (No. 1.1.1.2/16/I/001, agreement No. 1.1.1.2/VIAA/1/16/014, SEDA, Republic of Latvia) and by European Structural Funds project “Development of doctoral studies” (KD-17135, Research Council of Lithuania).

Luminescence of Erbium Doped Barium Lutetium Fluoride and its Dependence on Temperature and Erbium Concentration

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Studies of luminescence processes in various materials are still of great importance allowing to understand spectroscopic properties and their practical applications. In this work spectroscopic properties of $\text{Ba}_4\text{Lu}_3\text{F}_{17}:\text{Er}^{3+}$, their dependence on temperature (8-300 K) and activator ion Er^{3+} concentration (1, 10 and 40 mol%) were measured. This material is yet little described in scientific literature and could be a promising material for up-conversion luminescence. Therefore, it has many potential applications up-conversion lasers, temperature sensors, solar cells and others.

Luminescence and up-conversion luminescence spectra of polycrystalline powder samples excited in visible and infrared spectral region were measured in various temperatures. Site selective spectroscopy reveals different Er^{3+} arrangements in crystalline structure. Temperature dependence of phonon induced luminescence band broadening and changes in intensity were observed. Furthermore, luminescence decay kinetics of the dominant Er^{3+} spectral bands and its dependence from temperature were measured.

Based on acquired experimental data, the impact of Er^{3+} concentration and temperature on the luminescence process in the $\text{Ba}_4\text{Lu}_3\text{F}_{17}:\text{Er}^{3+}$ will be discussed in this work.

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Short-wave infra-red long persistent luminescence of $\text{MgGeO}_3:\text{Yb}^{3+}$ material

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Materials with long persistent luminescence have caused widespread interest among scientists and industry for decades. Right now there is widely available information on long persistent luminescence materials with emission within visible and near infra-red spectral range, however researches on materials with long persistent luminescence within so-called short-wave infra-red spectral range (from 900 nm to 1700 nm) despite the high potential in applications are in very small numbers.

In the course of this work MgGeO_3 material doped with ytterbium ions were produced in UL ISSP Laboratory of Spectroscopy using solid-state reaction synthesis with ytterbium concentration of 0,1 mol%.

The sample has undergone a structure study using X-ray diffraction analysis and optical spectroscopy measurements like excitation and emission spectra, thermally stimulated luminescence measurements, luminescence kinetics measurements. Based on the obtained experimental results conclusions about the short-wave infra-red long persistent luminescence processes of ytterbium doped MgGeO_3 material will be drawn.

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Structural investigations of $\text{CuMo}_{1-x}\text{W}_x\text{O}_4$ solid solutions

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Copper molybdate solid solutions with tungsten ($\text{CuMo}_{1-x}\text{W}_x\text{O}_4$) are interesting functional materials with several chromic-related properties including thermochromism, piezochromism, tribochromism and halochromism. Specific atomic and electronic structure makes it a promising inorganic compound in a wide range of technological applications.

At atmospheric pressure, pure CuMoO_4 exists in two phases – low temperature γ -phase with dark brown colour and high-temperature α -phase with green colour [1]. The hysteretic-type transition from the γ -to- α phase occurs in the temperature range of 230–280 K upon heating and is accompanied by drastic colour change. At the same time, the α -to- γ transition occurs between 120 and 200 K upon cooling [2, 3]. Furthermore, it is possible to tailor the properties of the molybdate by applying external pressure or by modifying its composition. Depending on the tungsten concentration, molybdate phases isostructural to high-pressure CuMoO_4 can be obtained in $\text{CuMo}_{1-x}\text{W}_x\text{O}_4$ solid solutions [1].

In order to understand the relationship between structural and thermochromic properties in $\text{CuMo}_{1-x}\text{W}_x\text{O}_4$ ($x=0-0.75$), we performed an X-ray absorption spectroscopy study at the Cu and Mo K-edges and W L_3 -edge. The analysis of the temperature-dependent Mo K-edge X-ray absorption near edge structure (XANES) in CuMoO_4 and $\text{CuMo}_{0.9}\text{W}_{0.1}\text{O}_4$ allowed us to follow the hysteretic phase transition. At the same time, the extended X-ray absorption fine structure (EXAFS) analysis allowed us to reconstruct the radial distribution functions and to characterize structural changes around absorbing atoms.

The work was supported by philanthropist SIA MikroTik and administrated by the University of Latvia Foundation.

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INVESTIGATION OF PHOTOLUMINESCENCE AND REDUCTION OF AMPLIFIED SPONTANEOUS EMISSION THRESHOLD VALUE OF CYANOACETIC ACID DERIVATIVE IN PVK MATRIX

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Currently, one of the promising and intensively developing technologies in which a different non crystalline structure films forming organic molecules can be used, are associated with organic solid-state lasers, where such molecules are widely used as laser dyes for the preparation of the laser active medium. In comparison with traditional inorganic lasers, they would be much cheaper and more easily integrated into photonic devices.

However, for the preparation of a laser active medium, can be used only those organic compounds in thin films of which is possible to excite amplified spontaneous emission (ASE). In this work were investigated PL and ASE properties of organic compound:polymer guest-host system, where organic compound in different concentration was mixed in polymer matrix. As organic compound was used one of the new original compound Ethyl 2-(2-(4-(bis(2-(trityloxy)ethyl)amino)styryl)-6-tert-butyl-4H-pyran-4-ylidene)-2-cyanoacetate (KTB), that in previous experiments with neat thin films showed low ASE threshold value [1]. In order to satisfy the requirements of a good planar waveguide, polyvinylcarbazole (PVK) was used as a polymer for preparing this system due to its high refractive index. Eight samples of described system, with 1 to 100 weight percent (wt%) concentration of organic compound in polymer, were made and studied. The influence of different weight percent of organic compound appears as a solid-state solvatochromic effect, which was observed as red shifting of ASE peaks positions, sequentially from 1wt% till 100 wt%, and lowering of ASE excitation threshold energy, reaching a minimum of $9 \mu\text{J}/\text{cm}^2$ at 20 wt%. Thin films of investigated compounds on glass substrate were made from chloroform solution by the spin-coating method. Photoluminescence and photoluminescence quantum yield was excited at pure KTB absorption maximum wavelength: 479 nm. Amplified spontaneous emission was excited by Ekspla 310 series pulse laser at 479 nm wavelength. The irradiation area on the surface of the sample was stripe form with dimension $3 \times 0.4 \text{ mm}^2$. Light emission was collected at the edge of the sample and measured by spectrometer OceanOptics HR4000. Influence of KTB doping concentration effect on light emission properties, reduction of ASE threshold value and its perspectives for future use as laser dye in red lasers will be discussed

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Photoluminescence of $\text{Eu}^{3+}/\text{Tb}^{3+}$ doped glass-ceramics containing SrF_2 nanocrystallites

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The luminescence of rare earth (RE) ions is applied in lighting devices including LEDs, WLEDs and sensors, scintillators etc. In order to develop a competitive luminescent material, choice of a proper host material is essential. Oxyfluoride glass ceramics are perspective luminescent materials due to the high durability and low phonon energy they possess.[1] In fluoride nanocrystallites, the substitution of cations by dopant (RE) ions can be achieved allowing to optimise the luminescence intensity and luminescence colour properties of the RE ions.

$\text{Tb}^{3+}/\text{Eu}^{3+}$ co-doped materials are characterized with an intense luminescence and are used in commercial white lighting sources.[2] Tb^{3+} emits strong luminescence in green spectral range while Eu^{3+} in the red spectral range. The energy transfer between the ions is reported which can modify the colour of the emitted light.

In the present study, luminescence of europium and terbium in glass-ceramics containing SrF_2 nanocrystallites have been investigated in order to analyse the impact of the local structure on RE ion luminescence and energy transfer.

In the present study, oxyfluoride glasses with the composition $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-Na}_2\text{O-SrF}_2$, activated with Tb^{3+} and Eu^{3+} ions (0-1 mol%) have been synthesized via melt quenching method. The glass-ceramics containing SrF_2 nanocrystallites were obtained by annealing the as-made glasses at 650, 680 and 700 °C temperature for 1 hour. Luminescence emission, excitation and decay measurements have been performed.

In the glass ceramics, luminescence spectra of Eu^{3+} and Tb^{3+} ions indicate a partial incorporation of RE ions in SrF_2 nanocrystallites, both in singly doped and co-doped samples. This observation is supported by the increase of luminescence decay times in the glass ceramics compared to glasses. The energy transfer from Tb^{3+} to Eu^{3+} ions is observed and its efficiency in glasses and glass-ceramics has been estimated. The colour properties of the emitted light are analysed.

This work was carried out thanks to SIA Mikrotik donation. Donations are administered by the University of Latvia Foundation.

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Electroluminescence properties of OLEDs containing iridium (III) complexes

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Research and application of organic light emitting diodes (OLEDs) are growing rapidly during last decades. Most broadly investigated material class is cyclometalated iridium (III) complexes by reason of their good photophysical and chemical properties. Moreover, attaching different ligands allows good color-tuning possibilities.

In this study as emitters newly obtained solution-processible compounds containing heteroleptic iridium (III) complexes and carbazole were chosen for OLEDs'. To main compound two different ancillary ligands were added - acetylacetonate (*acac*) and 2-picolinic acid (*pic*).

Using two different matrixes, poly(9-vinylcarbazole) (PVK) and 4,4'-Bis(N-carbazolyl)-1,1'-biphenyl (CBP), two series of OLEDs was created:

- (device-I) ITO/PEDOT:PSS(40 nm)/ emissive layer (60 nm, PVK:emitter 20 wt%)/ BPhen (20nm)/LiF(1 nm)/Al(100 nm);
- (device-II) ITO/PEDOT:PSS(40 nm)/ emissive layer (60 nm, CBP:emitter 20 wt%)/ TPBi (20nm)/LiF(1 nm)/Al(100 nm).

Hole-injection Poly(3,4-ethylenedioxythiophene) - poly(styrenesulfonate) (PEDOT:PSS) and emissive layers were created using a spin-coating technique, electron transport bathophenanthroline (BPhen) or 2,2',2''-(1,3,5-Benzinetriyl)-tris(1-phenyl-1-H-benzimidazole) (TPBi) and electron-injection layers, as well as cathode by thermal evaporation in a vacuum.

TPBi was used for CBP matrix and BPhen for PVK matrix in order to achieve best possible energy level alignment between host and electron transport layer.

The best outcome was attained using CBP matrix regarding luminance, external quantum, current and power efficiencies. Moreover, adding *pic* ancillary ligand allows to gain 2.39 times higher luminance, 1.52 external quantum efficiency, 1.69 - current efficiency and 1.59 - power efficiency, comparing to *acac* ancillary ligand. Turn-on voltage of the devices was about 6 V.

Newly obtained compounds can be successfully used as solution-processible emissive layers in OLEDs as they show better results comparing to previously investigated structurally similar materials [1], [2].

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Whispering gallery mode resonator temperature sensor

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The whispering gallery modes (WGM) resonators are based on spherical objects, which are made from optically transparent materials, and is capable of maintaining an circling optical wave, inside the sphere, using total internal reflection. If there is a light source which supply the sphere with constant intensity, the wave moving along the perimeter of sphere starts constructively interfere. In this case the resonance happens, which is called whispering gallery mode (WGM). When there is a change in temperature, it changes the radius of WGM resonator, and that results in change of reflection coefficient, which results in change of resonance and intensity. The current work is being done in direction of the possibility of using WGM resonators as temperature sensors. Using various temperatures and different diameter spheres to test the resonance and calibrate equipment. Also making a practical system for temperature measuring using WGM resonators, laser and self written MATLAB computer program, that recognizes when WGM resonators start to resonate. At the same time in the current work there are theoretical modelling being done of light in WGM micro resonators using COMSOL Multiphysics software with Wave Optic Module. Prism resonator systems are being described.

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Vision Science: invited speakers

Imaging the eye: structure, function and window to the body

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The eye is the only tissue of the human body that is transparent to optical radiation. This makes it ideally suited for inspection by non-invasive optical methods. Ocular imaging started by addressing the need for structural assessment in the context of ophthalmological practice and evolved towards functional imaging of ocular tissues. Currently, the eye is also regarded as a window to the cardiovascular and nervous systems.

In this talk, we will present our past and present work in ocular imaging. We will travel from the assessment of corneal microstructure and functional evaluation of blood-retinal barrier permeability to current work on corneal metabolic imaging. Very recent data on neurodegeneration detection using optical coherence tomography data from the retina will be presented. Finally, the talk will address our ideas for future research on using the eye as window to the central nervous system.

Vision Science: student talks and posters

Relative depth estimation depending on spatial layout of stimuli on a volumetric display

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The innovative volumetric multiplanar display produces three-dimensional (3D) images in a physical 3D space. Thus, the depth perception can be ensured by providing numerous depth cues [1]. For simulated 3D images, visual performance non-uniformities were reported regarding the spatial location of stimuli [2]. The best performance was registered when the stimuli were presented in the upper and right visual fields. Presumably, these findings relate to the analogous asymmetries in the mechanism of extrapersonal attention [2] and faster eye movements in the horizontal direction compared to the vertical one [3]. Are similar performance non-uniformities observable for the relative depth estimation of volumetric 3D stimuli?

Young adults accomplished a depth estimation task on the volumetric multiplanar display (LightSpace Technologies, x1405) at seven randomized viewing distances (varied from 0.5 m till 2.0 m, with a 0.25 m step). In each trial, four 0.5° circles were presented on the display at 1.9° eccentricity. Two circles were demonstrated at eye level (further referred as the horizontal group), one - above it, and one - below (further both referred as the vertical group). The relative depth of one circle was different from others. The task was to determine the closest circle and submit the answer using the keyboard.

At the closest viewing distance, the average correct response rate peaked (0.99 ± 0.01) and no significant differences were found comparing the data for the horizontal and vertical group. However, the non-uniformities were spotted in the correct response rate at the larger viewing distances. Specifically, the rate reached 0.57 ± 0.03 for the horizontal group and 0.34 ± 0.03 for the vertical group when the depth estimation task was accomplished at 2.0 m viewing distance. In addition, the response time was slightly slower for the vertical group.

To sum up, the relative depth of stimuli on the volumetric display was estimated correctly and quickly at the close viewing distances. The superior performance was demonstrated for the stimuli at eye level compared to the stimuli above and below it at the viewing distances larger than 1.0 m.

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Macular pigment optical density in school-age children

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Macular pigment carotenoids lutein, zeaxanthin and meso-zeaxanthin protect the retina from oxidative stress and high-intensity blue light. These carotenoids have a dietary origin and are accumulated not only in the retina, but also are stored in fat. The previous studies in adults show that there is an inverse relationship between body mass index (BMI) and macular pigment optical density (MPOD) [1, 2]. A little attention has been paid to pediatric population and MPOD studies and no effect of BMI on MPOD in children has been found [3]. Several researches have analyzed other factors such as gender, age, iris colour and foveal thickness effect on MPOD values. The aim of the current study was to determine MPOD in school-age children and its relationship with BMI and other factors such as eye iris colour and gender.

In total, 112 children from Marupes elementary school were enrolled in this study. MPOD was measured in both eyes by *Macular Pigment Screener (MPSII)*, which is based on the method of heterochromatic flicker photometry. Children height and weight were used to calculate BMI.

The pilot study results consisted of 48 children (range 6-14 years). The mean MPOD in examined children was 0.39 ± 0.17 d.u. We found no difference between both eye results (*one-way ANOVA*, $F=0.11$, $p=0.75$) and no effect of ocular dominance on MPOD (*one-way ANOVA*, $F=2.10$, $p=0.16$). There was also no significant difference between boys 0.44 ± 0.21 d.u. ($n=19$) and girls 0.36 ± 0.13 d.u. ($n=29$) MPOD values and there was also no effect of blue, green and brown iris colour on MPOD values. The inverse relationship between BMI and MPOD as in adults was not found, because most of children had high BMI and more data with normal and reduced BMI is required to compare these factors.

This is the first study in Latvia that provides MPOD values for healthy school-age children which can be later used as a reference point for other studies. In our study the mean MPOD value was comparable to other studies, but our obtained data do not show association between MPOD and BMI, iris colour, ocular dominance or gender. The study sample is too small, and we require more valid data to confirm our conclusions and to suggest *MPSII* as the valuable screening method for children.

This research was funded by the donation of SIA Mikrotikls and the Foundation of the University of Latvia (the project No. 2184 "Development of environment for visual ergonomics studies").

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Gaze parameters for analysis of ambiguous geometric shapes

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Based on visual grouping principles, visual system combines individual elements into larger objects. Pinna [1, 2] demonstrated that visual grouping affects shape perception, which can easily be altered by changing the location of additional elements. Although the impact of visual grouping on shape perception has been extensively studied before, the link to direct attentional processes and gaze parameters has not.

The aim of the current study is to analyse gaze parameters in visual grouping tasks. Eye movements were recorded using IViewX RED500 eye tracker. 31 stimuli were presented to the participants: a square, a diamond, and a diamond with an additional element at its vertex, edge or intermediate position in 3 different distances. Participants in group 2 (n=7) participated in the eye tracking experiment, by sequentially attending all of the stimuli. Participants in group 1 (n=50) performed a forced-choice task where they had to determine the shape of an object (i.e., whether the object is perceived as a square or as a diamond).

Results indicate that the position of the ball and the distance to the additional element do not show a significant impact on the participants' shape perception. There was no significant difference in perception of the shape, depending on the location of an additional element, and its distance to the object and depending on the object size changes. Gaze was more divided between the objects when located further away from each other.

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Form and color perception in children

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Asking Italian children to draw a yellow square, they took a black pastel, drew a contour of the square and only then colored it yellow [1]. Mostly, 13 years old children drew only a yellow contour of the square and a full-filled yellow square. These results and the first measurements lead to the certain questions. Do children perform the task differently due to the impact of 1) language features (for instance, in Italian, '*quadrato giallo*' means 'square yellow' - adjectives follow the nouns), 2) culture, or 3) training method of kindergarten teachers? It was concluded [1] that, to perceive the color of an object, it is not necessary to have full-filled and perfect color inside the object. The aim of this study was to evaluate the impact of language and age on form and color perception in Latvian speaking and Russian speaking children.

121 preschool children (4-7 years old) and 130 primary school children (7-10 years old) from Latvian and Russian groups participated in this research. Latvian children received the instruction of tasks in Latvian, and Russian children - in Russian. The study was divided into two parts. 157 children were asked to draw colored geometrical figures in Part No 1. Every child had a paper and 6 pastels (hues: blue, green, black, yellow, red, brown). The task was to draw a color and a figure (for example '*zils trijsturis*', '*sarkans kvadrats*'). The sequence of the given task was varied for each participant. 251 children saw the different full-filled triangles in the Part No 2. The task was to outer the line around all blue triangles. Each participant was given different placements of painted triangles. 84% children represented only the contour of the figure in the named color, 14% drew the contour of the figure and full-filled the figure in the named color and two children drew and colored the circle, but not full-filled other figures. Two children used grey pencil to draw contour and then colored the figures. There was not found any statistically significant difference in data of Latvian speaking and Russian speaking children. Everyone drew contours in the named color. 22 children (14%) did not distinguish triangles from other geometric figures, especially, 4-5 years old. 69% four years old and 8% five years old children did not know the geometric figure-triangle. In the research No.2 the most (97%) circled triangle was with blue contour, completely colored. The second most often circled (89%) triangle was with a black contour, completely colored. The triangle, which was partially colored blue, was also perceived and marked as a blue triangle (amodal coloration).

Most children drew only the contour of figure in asked color. The idea and the ability to identify and distinguish geometric shapes significantly improves at the age of 6. The younger is the child, the greater is the amodal coloration perception. We suppose that the amodal perception has the influence of kindergartens teaching methods more than the impact of language.

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Fixation disparity and accommodation response in various contrast conditions

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Vergence and accommodation are interacting (in the near triad) to form single and clear image of the fixation target. However, various contrast conditions create an extra stress for vergence and accommodation. Some studies demonstrate that crossed fixation disparity (a small error of vergence response) dominates while reading black letters on white background and uncrossed fixation disparity dominates while reading white letters on black background.

The aim of our study was to analyze the effect of stimulus contrast on fixation disparity and accommodation response. 10 participants (21-24 y.o.) had fixation disparity evaluation using eye tracker IViewX Hi-Speed and 10 participants (20-30 y.o.) had accommodation evaluation using PowerRef-3. The experiment had two parts for all participants: (1) 3-5 letters long logical Latvian words with positive (1043 units) and negative (-1.00) Weber contrast; (2) the same stimuli but with various negative Weber contrast level (-0.16, -0.31, -0.44, -0.61, -0.86, and -0.98).

The results show statistically significant difference between fixation disparity and accommodation response in positive and negative contrast conditions; fixation disparity became more uncrossed and accommodation response slightly increased in positive contrast conditions. Decreasing the negative contrast of the stimuli, the tendency was observed only in low contrast conditions (-0.16, -0.31, -0.44); fixation disparity became less uncrossed and accommodation increased. It is important to take into account the contrast level and polarity of stimulus in studies of fixation disparity and accommodative response, especially using low contrast stimuli.

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Colour ensembles

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It is considered that humans without colour vision deficiencies can resolve up to $3 \cdot 10^5$ colours, but the truth is that this fact illustrates maximum resolution of our visual system, which can be demonstrated only in laboratory by using specifically designed stimuli. Aim of our research is to explore what amount of colour diversity is noticeable by a standard observer.

In order to study our colour perception capacity, we suggest to narrow the spectrum of coloured stimuli, which are used in the experiment, to the redgreen colour opponent channel. By narrowing measurements down to the red-green channel, we expect to avoid stimulating blueyellow and achromatic colour opponent channels, as well as interactions between colour and achromatic channels. The main aim of this research is to develop stimuli and methodology to study our capacity in resolving coloured stimuli within one colour opponent channel.

Colour monitor Samsung S24C650XW with 8 bit colour resolution was colour calibrated with Photo Research PR-655 spectroradiometer. Each of RGB channels was calibrated separately and RGB corresponding to luminance functions were calculated. Stimuli for redgreen colour channel were calculated considering that the sum of L and M cone excitations was constant, and S cone excitation was kept constant, too. In order to study the red-green colour channel resolution, we suggest the novel stimuli, which enable us to measure the colour diversity thresholds directly within one colour opponent channel. To this day, we have solved the most of technical challenges, developed the methodology and psychophysical algorithms for colour diversity threshold measurements.

Colour category boundary between light and dark blue in Russian language

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It is considered that humans are able to resolve up to $3 \cdot 10^5$ colours. It is well known fact that all colour sensations can be categorized in 11 colour categories in most of modern languages. However, there are the few languages, in which all colour sensations are categorized in 12 categories. Additional colour category is devoted to stimuli of blue end of visible light spectrum in order to separate light and dark blue colours. Aim of our study is to study colour category boundaries between light blue and dark blue in Russian language.

Colour monitor Samsung S24C650XW with 8 bit colour resolution was colour calibrated with Photo Research PR-655 spectroradiometer. Each of RGB channels was calibrated separately and RGB corresponding to luminance functions were calculated. In order to find Munsell chip colour values for specific computer monitor, we used CIE Lab colour coordinates of Munsell chips (H. Van Aken) and calculated corresponding CIE xy and RGB values.

In order to measure the boundary between light blue and dark blue category, the method of constant stimuli was used. During measurement session, the stimuli with constant lightness and chroma values were presented. Test subjects were asked to categorize stimuli in one of two colour categories if possible (the third category was offered if the test participant viewed the coloured stimuli that did not belong to the following colour categories: light blue and dark blue). The obtained results were ambiguous, because of that, further experiments with this design were discontinued. To improve the methodology, it was decided to use the adaptive psychophysical method 1 up and 1 down. Further colour boundary experiments were carried along brightness axis. Latest experiment design enables colour category boundary measurements, but still it needs some polishing. Up till now, we have developed the computer program and methodology to measure colour category boundaries.

The impact of keratoconus apex's localization on eye aberrations

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The main optical error source in the keratoconus is the anterior corneal surface [1]. The anterior corneal surface makes the keratoconus subjects' total ocular aberrations. Keratoconus subjects have 3.74 times higher the total ocular and corneal wave front aberrations comparing to healthy eyes [2].

The corneal anterior and posterior surface aberrations of 3rd and 4th order were measured in keratoconus subjects with different keratoconus stage (27 eyes with the first, 31 with the second and 21 with the third stage keratoconus) and with the different apex localization (33 with the central and 46 with the peripheral keratoconus apex). The highest order aberrations were measured with videokeratoscopy for 8 mm cornea.

The vertical coma and the spherical aberrations were the dominant keratoconus subjects' aberrations. Subjects with a central apex had the higher comatic aberration than subjects with a peripheral apex. The comatic aberration had statistically significant differences between the first and the third keratoconus stage ($p=0.03$) to anterior corneal surface and between the first and the second keratoconus stage ($p=0.05$), and the first and the third keratoconus stage ($p=0.05$) to posterior corneal surface by Mann-Whitney test, but not for keratoconus subjects between central and peripheral apex ($p=0.51$). The spherical aberration had the statistically significant difference between the first and the second keratoconus stage ($p=0.04$) and the central and the peripheral apex ($p=0.008$) to cornea's anterior surface.

The image on retina has the reduced vision quality due to aberrations and the subjects' eye aberrations have the impact on the high contrast visual acuity and the contrast vision sensitivity. The increased aberrations are the main reason why subjects with keratoconic eyes experience reduced quality of vision.

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Interactive three-dimensional visual search by radiologists and residents

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Many of the most important professional tasks performed by the radiologists can be defined as visual search tasks. Radiologists review numerous images and interact with them to detect the slightest changes in the anatomical structures [1]. Moreover, their visual search abilities are frequently challenged because of physical properties of the images, for instance, high target-distractor similarity and low contrast. The visual search performance and strategy of radiologists varies significantly depending on their expertise when reviewing the professional images [2]. This study aimed to determine whether differences in visual search can be spotted also for non-medical volumetric images.

In total, 18 medical professionals participated in the study. They were divided into two groups: nine certified radiologists (professional experience more than 5 years, on average, 22 ± 11 years) and nine resident-radiologists (professional experience less than 5 years, on average, 2 ± 1 years). They completed non-medical three-dimensional visual search tasks that were presented on the volumetric multiplanar display (LightSpace Technologies, x1406). The target-distractor similarity and set size varied in the tasks. The subjects could interact with the presented stimuli by moving them forth and back on the display planes.

The visual search time and search slope did not differ significantly among two groups. Only slight differences were observed in the correct response rate when the target-distractor similarity was high. However, the number of interactions was considerably greater (on average, at least 1.5 times) among residents compared to radiologists in all visual tasks, probably, due to different search strategies.

Thus, it can be concluded that the radiological experience does not influence significantly the outcome in the three-dimensional non-medical visual search on the volumetric display. At the same time, the differences can be reflected in the way how professionals accomplish the interactive visual tasks.

The authors appreciate the support from LightSpace Technologies Incorporation and the University of Latvia (the project "3D volumetric screen and the functionality of visual system"), as well as the donation of SIA Mikrotikls and the Foundation of the University of Latvia (the project No. 2184 "Development of environment for visual ergonomics studies"). Thanks to radiologists and residents for their active involvement, enthusiasm and provided feedback. The authors also thank Reinis Pitura for his valuable help, support and ideas.

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Topographical changes of the cornea after sleeping in soft contact lenses

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Introduction: According to U.S. Centers for Disease Control and Prevention (CDC), approximately 45 million people in the U.S. wear contact lenses. Around one third of them have reported that they sleep in them. Sleeping in contact lenses is the most common offense [1]. This phenomenon among contact lens wearers is observed not only in the U.S., but also elsewhere in the world. Sleeping in daily wear contact lenses does not only increase risk for eye infection, but can also lead to corneal damage. Since the corneal surface is the major refracting element in the eye, even minor changes in its shape can alter the visual acuity [2]. A contact lens is placed directly on the cornea, therefore it is possible to obtain the best possible visual acuity. Soft contact lens manufacturers claim that soft lenses are inert and have no effect on the cornea.

Objectives: To evaluate topographical changes of the cornea after sleeping in soft contact lenses.

Materials and methods: Thirty-four myopic eyes were evaluated. Corneal topography was performed before wearing contact lenses and next day after sleeping in them. Thirteen regions (Temporal-2, Temporal-1, Temporal, Superior-Temporal, Superior, Superior-Nasal, Inferior-Nasal, Inferior, Inferior-Temporal, Central, Nasal, Nasal-1, Nasal-2) were analyzed. Corneal topography data were collected using Oculus Keratograph. Statistical analysis was performed using Microsoft Excel and IBM SPSS software.

Results: The absolute impact of contact lenses on the patient's eyes was evaluated. Before and after data was assessed using paired t-test. Temporal-2, Temporal-1, Temporal, Nasal, Inferior-Nasal, and Nasal-1 regions mean values changed by 3 mm ($p < 0,05$). Superior-Temporal, Superior, Superior-Nasal, Inferior, Central and Nasal-2 regions mean values changed by 4 mm ($p < 0,05$). Superior region mean value changed by 2 mm ($p < 0,05$). In thirteen eyes (38% of cases), significant changes were in more than 50% of regions.

Conclusion: Statistically significant changes were noted in all regions. One-third of the eyes had significant changes after sleeping in contact lenses in more than 50% of regions. We observed transient changes in the corneal topography induced by contact lenses. Despite some contact lenses being approved for overnight wear, many doctors still do not recommend that.

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Visual stimuli eccentricity affects depth perception for a volumetric display

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Previously, it was shown [1] that the relative depth estimation based on binocular depth cues was correct when the stimuli were located close to each other on the volumetric multiplanar display [2], but the performance outcome declined when the stimuli were presented at 7.6° , although the gaze fixations were not limited to the center of the display. In this work, we further explore how this effect manifests at different viewing distances.

Twenty three young adults took part in the study. The visual stimuli (four achromatic circles with angular size of 0.5°) were presented at 3.8° and 7.6° eccentricities on a volumetric multiplanar display (LightSpace Technologies, x1405). The tasks were performed at 0.50 m and 0.75 m viewing distances. The subjects determined which one of the circles was located closer to them comparing to all other circles on the display planes. The answer was submitted by pressing the corresponding arrow on the computer keyboard. The task execution time was unlimited, but the subjects were instructed to act accurately and quickly.

A drop in the visual task performance was observed in relation to increase of stimuli eccentricity at both viewing distances. However, the results of this psychophysical experiment revealed that the related changes in correct response rate and time were different. To be specific, the growth of average response time was considerably less pronounced for 7.6° eccentricity in comparison to 3.8° eccentricity when increasing the viewing distance. Nevertheless, the correct response rate changed approximately to the same degree for stimuli at both eccentricities.

On the whole, the relative depth based on binocular depth cues becomes more difficult to be estimated correctly if the eccentricity of visual stimuli increases on the volumetric display. The response time can be more affected than the correct response rate by the change of viewing distance.

This research was supported by LightSpace Technologies Incorporation and the University of Latvia (the project "3D volumetric screen and the functionality of visual system"), the donation of SIA Mikrotikls and the Foundation of the University of Latvia (the project No. 2184 "Development of environment for visual ergonomics studies").

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Eye tracking analysis in perception of camouflage

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Camouflage provides hiding an object in the environment, making it difficult for the visual system to recognize it [1]. Until now the Latvian Army has used four types of camouflage patterns - US m81 Woodland (1992, ERDL), LatPat (2007, Saab Barracuda), MultiLatPat (2015, Saab Barracuda, NFM) and the new Latvian Army camouflage (2018). Since eye movement analysis is an objective measurement of visual attention that allows measuring the conscious and unconscious part of attentional processes [2], the aim of the current study is to evaluate the efficiency of camouflage developed by the Latvian Army (2018) with the help of eye tracking system IViewX RED500.

Four participants (20 to 22 years old) with no additional expertise in military camouflage participated in the experiment. Participants were presented with 4 images with the natural environment of Latvia (forests, meadows, swamps) and 4 types of camouflage patterns, which were located on each background in 4 different locations.

The results demonstrate that the longest time for object detection (time of first fixation) was observed on the patterns of LatPat and MultiLatPat camouflages. The shortest first fixation time and thus the shortest time for object detection was observed when attending the images of the swamp and meadow. The longest dwell time was for MultiLatPat and the newly developed camouflage. The highest average fixation time was observed on Woodland and MultiLatPat camouflage elements.

The study demonstrates that eye movement analysis can give an insight into the perceptual processes different camouflage elements, demonstrating differences between the first fixation time, dwell time and average fixation duration.

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Development of a comparative eye structure table

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Optometry is a healthcare profession that is concerned with eyes and structures, vision and the visual system. In Latvia, the optometrist is the first person to go to if you feel some changes in your vision. Optometrists are trained to act as effective screening agents for ocular pathological conditions like cataract, macular diseases, glaucoma and others [1]. But it is hard to evaluate changes in the eye structures because there are no specific norms - each eye is different [2]. So you have to look for signs to confirm the diagnose. I have developed the chart to help optometrists diagnose the eye structure problems from ocular signs that will help to distinguish pathological and out of norm changes.

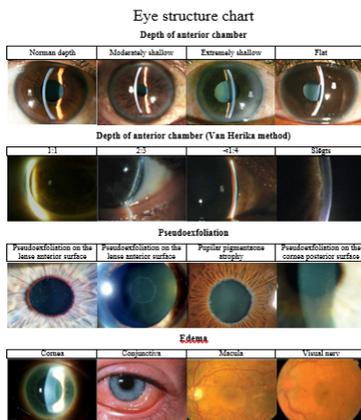


Figure 1: Evaluation of anterior chamber, pseudoexfoliation and edema in eye structures.

I have developed the eye structure chart, which contains 21 sections, 104 images. The structure chart shows anterior chamber depth, pseudoexfoliation, visual nerve disk size differences, edge variations. It helps to distinguish eye structures where optometrists see pathological changes like edema, hemorrhages, neovascularization. The chart shows signs of specific retinal tears and distinguishes whether they are malignant or benign. In diabetic retinopathy and age related macular degeneration (AMD), it is common to see drusen and the chart shows that.

The eye structure chart helps you to distinguish norms from pathological changes. It provides optometrists with a simple tablet that can be used in every day practice.

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Laser Physics and Spectroscopy: invited speakers

From Quantum Mechanics to Atomic Spectra

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Quantum Mechanics (QM) provides theory to describe physical processes in an atomic scale. Typical QM courses [1] provide only general formulas which are not enough detailed to model phenomena observed in experiments, for example, atomic spectra of Rb atoms. For this purpose advanced courses like Atomic and Optical Physics, and Atom - Light interaction [2,3] has to be introduced. Current lecture provides and explains general formulas of QM and shows their developments that lead to advanced formulas that can be used for modelling experimental data of atomic spectroscopy.

Quantum Mechanics has started with a revolutionary assumption that a particle with momentum p is related to "matter wave" with wavelength λ_D :

$$\lambda_D = \frac{h}{p} \quad (1)$$

where h is Planck's constant.

Schrödinger's equation describes the evolution of a "matter wave" of a particle and thus is a basic equation of QM:

$$i\hbar \frac{\partial}{\partial t} \Psi(r, t) = \hat{H} \Psi(r, t) \quad (2)$$

where \hat{H} is Hamiltonian operator:

$$\hat{H} = -\frac{\hbar^2}{2m} \Delta + U(r, t) \quad (3)$$

where m - mass of a particle, Δ - Laplace operator, and $U(r, t)$ - external potential.

If potential is stationary $U(r, t) = U(r)$, then $\Psi(r, t)$ can be described as

$$\Psi(r, t) = \Psi_r(r) \Psi_t(t) \quad (4)$$

In this case

$$\frac{1}{\Psi_t(t)} i\hbar \frac{\partial}{\partial t} \Psi_t(t) = \frac{1}{\Psi_r(r)} \hat{H} \Psi_r(r) = \text{const.} = E \quad (5)$$

$$\Psi_t(t) = \text{const.} \cdot e^{-i \frac{E}{\hbar} t} \quad (6)$$

$$\hat{H} \Psi_r(r) = E \cdot \Psi_r(r) \quad (7)$$

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Laser Physics and Spectroscopy: student talks and posters

OPTICAL FILAMENT INDUCED LUMINESCENCE IN LASER MEDIA

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Luminescence – light emitting process when electron jumps from excited to a ground state. In order to observe this process within transparent medium a very strong electromagnetic field is required. Such intensities could be reached during experiments as cathodoluminescence, X-ray luminescence, photoluminescence, etc. In this work we are offering to use filaments of light in order to investigate luminescence spectrum and associated decay of excited states. This method is more convenient compared to cathodoluminescence or X-ray luminescence because specimen is excited by laser beam. In this way, we have system which is easily adjustable and has cheap, simple optics. Use of filaments in luminescence spectroscopy is a nondestructive way to examine transparent solid material in order to determine laser media quality.

Filament occurs when femtosecond laser pulses are focused onto transparent medium and generates wide spectrum coherent radiation – white light continuum. When light self-action occurs laser beam shrinks to micro-meter size and pulse spectrum spreads over several octaves. Filament excites impurities and charge carriers within medium. In this experiment luminescence is observed and registered from the side of the filament. In order to compare the optical quality of popular laser media crystals such as YAG, A_2O_3 and KGW, provided by different manufacturers spectra and luminescence decay characteristics were measured. By analyzing spectrum induced by light filament, it was possible to identify undesirable impurities and their amount in crystals. Luminescence decay measurements exposes the lifetime of states and reveals correlation between them.

In conclusion, filament luminescence is suitable way for medium quality investigation because different manufacturer specimens creates specific luminescence spectra, varying in distribution of intensity and characteristic peaks.

Spectrum of YAG crystals reveals that intensive luminescence could be generated by lattice defects and transition metals. The spectra reveals a trace amount of Chromium ions. Non-homogeneous decay in short wavelength range was observed, possibly due to higher energy electron transition to lower energy states, within the band.

Luminescence in Sapphire could be generated by F^+ center defects and transition metal ions. The decay of the peak in UV region is correlated to peak in IR, which could indicate a transition between two distinct energy states (Fig. 1).

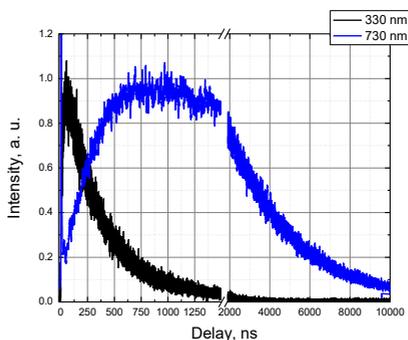


Fig. 1. UV region luminescence decay correlation with IR region.

Luminescence peaks in KGW crystals could be created by rare earth and transition metal ions. KGW spectra hints that there is Europium and Terbium ions. The associated decay reveals that these ions creates long-lasting phosphorescence states, with possible impact on high repetition rate applications.

CALCULATION OF THE ETHANOL TORSIONAL SPECTRUM AT THE CBS LIMIT

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An ethanol molecule possess a number of interesting properties. In particular, such molecules can form clusters through intermolecular hydrogen bonds formation and can exist as two conformers with energy difference of only 40 cm^{-1} . Furthermore, it has two internal tops connected by kinematic and force interactions. Earlier the ethanol molecule torsion spectra were calculated in MP4/cc-pVTZ [1] and B3LYP/acc-pVQZ [2] approximations. However, calculated frequency value of the methyl group fundamental torsion vibration turned out to be overestimated in both cases in comparison with the experimental value. In addition, the magnitude of splitting for hydroxyl group in first excited torsion state, which in [1] turned out to be even smaller ($0,2 \text{ cm}^{-1}$) than the corresponding splitting for the ground state ($3,5 \text{ cm}^{-1}$), caused a range of questions. Although this splitting value in [2] turned out to be greater ($6,5 \text{ cm}^{-1}$), still it seems to be underestimated. In the present work 2D potential energy surface (PES) was calculated using MP2/cc-pVTZ and MP2/cc-pVQZ approximations. Then, within the framework of the developed methods, data extrapolation to the complete basis set (CBS) was carried out. Extrapolated data were used to calculate torsion spectrum of the molecule. Analysis of the results obtained showed that a number of calculated frequencies for transitions between trans- and gauche- conformers are in better agreement with experimental data. However, the fundamental torsion vibration frequency of the methyl group turned out to be even higher than that obtained in [1,2]. It allowed us to suggests that the experimental value of corresponding vibration frequency is actually in $260\text{-}300 \text{ cm}^{-1}$ spectral range. This assumption can be in agree with the results obtained in recent work [3] where Raman ethanol spectrum has been registered and the Raman line 290 cm^{-1} has been assigned to one of the methyl group transitions.

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FEATURES OF USING THE DVR METHOD FOR METHANDIOL MOLECULE TORSION SPECTRUM CALCULATION

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Torsion spectrum of the methandiol molecule (MD) is undoubtedly of great interest but as far as we know it has not yet been calculated. For 2D potential energy surface (PES) calculations B3LYP/acc-pVQZ approximation was used. Two torsion coordinates, defined as the rotation of hydroxyl groups relative to C-O bonds, have 2π period and both range from 0 to 2π . The usage of the DVR method requires correct specification of the number of intervals and the initial value of torsion coordinates. An important property of MD is the presence of O-C-O fragment that defines the reference plane. Positions of hydroxyl groups when they are located in O-C-O plane at the maximum distance have been selected as zero values of two torsion coordinates. Each 2π interval was divided into 15 sub intervals, and nodes of two-dimensional grid were chosen at their centers. Taking into account $U(\varphi_1, \varphi_2) = U(2\pi - \varphi_1, 2\pi - \varphi_2)$ equation for potential energy, we have 12, 36, 60, 84, 108, 132, 156, 180, 204, 228, 252, 276, 300, 324 and 348 values for φ_1 coordinate, with 12, 36, 60, 84, 108, 132, 156 and 180 for φ_2 coordinate. Calculated 2D PES is shown in Fig.1.

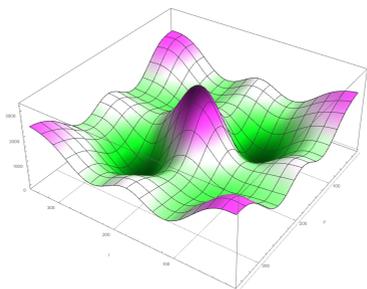


Figure 1: 2D PES of MD molecule calculated in B3LYP/acc-pVQZ approximation.

As one can see from Fig. 1, 2D PES has two pairs of equivalent global (with C_2 symmetry) and local (with C_S symmetry) minima. Both pairs are separated by a quite high potential barrier. In accordance with calculation results, the frequency of tunneling between two global minima turned out to be very low ($0.0001923 \text{ cm}^{-1}$). Calculated frequencies of hydroxyl groups lowest torsion vibrations are 330, 386, and 652 cm^{-1} . Each of the vibrations is twice degenerate. The first torsion vibration is antisymmetric with respect to C_2 axis, while the second is symmetric. The doubling of all three of the above mentioned vibrations is associated with symmetry or antisymmetry relative to the configuration analogue.

Determination of chemical composition of micrometeorites by laser-induced breakdown spectroscopy

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Micrometeorites are small (up to 0.5 mm) extraterrestrial particles of dust that have mainly asteroid and comet origin. In contrast of rare large meteorites, micrometeorites fall to the Earth daily and accumulate on its surface [1]. In this study, at the first time in Belarus micrometeorites were found and their chemical composition was established by laser-induced breakdown spectroscopy.

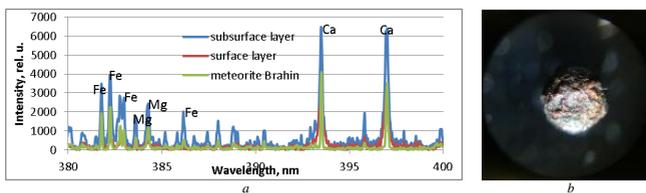


Figure 1: Emission spectra of iron part of Brahin meteorite and one of the iron micrometeorites (a). Microscope image of one of the iron micrometeorites (b).

Firstly we have collected dust from the part of the roof of building before and after Earths passing through meteor showers. Particles with magnetic properties have been separated by a magnet. Then we viewed them through the microscope and took samples, which are similar to spherules, particles with unusual structure and color and particles looking as melted. Using Larsens classification [2] we have pre-selected samples of terrestrial origin and extraterrestrial particles supposed. The chemical composition of 82 particles was determined using double-pulse atomic-emission spectrometry. The analysis has been carried out using multichannel laser spectrometer (wavelength is 1064 nm, pulse duration is around 15 ns, pulse energy is 35 mJ, pulse-to-pulse time interval is 8 s). The thickness of the layer evaporating by laser ablation is 5 m, which makes it possible to perform a layer-by-layer analysis of the largest particles. The spectra of the iron and stony parts of the Brahin meteorite were used as reference spectra. Fig. 1a presents emission spectra of the iron part of Brahin meteorite and one of the samples (surface and subsurface layers). One can see that this particle has the similar chemical composition as the iron part of Brahin pallasite. The presence of such elements as Fe, Mg, Ca, and Ti has been established in the collected samples. Totally, 19 iron (see Fig. 1b) and 7 stony micrometeorites have been identified by laser spectral analysis.

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Determination of OH rotational temperature in thallium containing high frequency electrodeless lamps

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High frequency electrodeless lamps(HFEDL) are widely used as bright radiators of narrow and intense spectral lines in different types of scientific devices, for instance in atomic absorption spectrometers. For each particular use these light sources have to be optimized, and although knowledge of the temperature of heavy particles in plasma is not sufficient to understand and explain different processes, its measurement is important for the optimization of the plasma conditions in the light source.

In this work we are determining gas temperature values that were obtained from the OH spectrum. To determine temperature from intensity distribution in rotational bands of OH, relation is used(See Eq.(1)) [1]:

$$\log\left(\frac{I \cdot \lambda}{A}\right) = \text{const} - \frac{0.625}{T_{rot}} E_i \quad (1)$$

Where I is line intensity, λ is wavelength, E_i is the excited energy state, T_{rot} is the rotational temperature and A is constant.

For investigation we used HFEDLs with thallium filling. To excite the plasma the lamp is placed in an electromagnetic field with frequency of 250 MHz. Then lamps are operated at different excitation generator voltage values (21 - 29 V). The emission spectra of the light sources are registered using spectrometer Jobin Yvon SPEX 1000M.

The preliminary results show that in emission spectra of Tl²⁰⁵I+Ar HFEDL molecular spectra of OH can be observed which can be used for rotational temperature determination. Obtained results show that determined temperature vary in the range of 1200-1400K.

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CONFORMATIONS AND ANHARMONIC IR SPECTRA OF THE METHANEDIOL MOLECULE

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Methandiol or methylene glycol is a very unstable molecule, which however is widely used in cosmetics and medicine. Furthermore, it is considered that this molecule can be contained in the interstellar space and gaseous clouds. That is why methandiol is the subject of intensive searches by astronomers. It would be naturally to assume that the only equilibrium geometry of this molecule is the configuration with C_{2V} symmetry (Fig. 1a). However, the interaction of oxygen atoms unshared electron pairs comes into play.

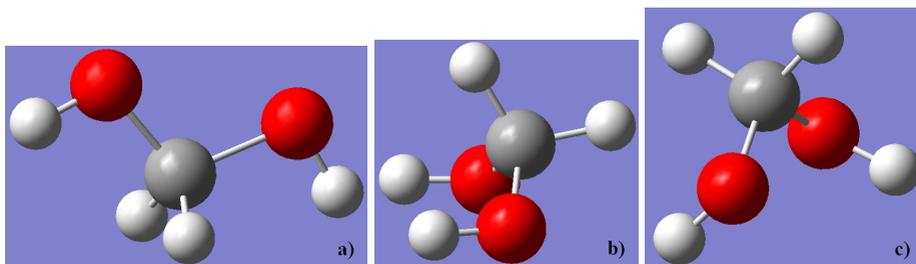


Figure 1: Different configurations of methandiol molecule with C_{2V} (a), C_S (b) and C_2 (c) symmetry.

As a result, stable conformers of the molecule have C_S and C_2 symmetry types (Fig. 1b and 1c, respectively). Within this work geometrical parameters of two conformers were calculated at wB97XD/acc-pVTZ level of theory. In accordance with calculation results, configuration with C_2 symmetry is more stable (conformer I), while conformer II with C_S symmetry has the energy of 888 cm^{-1} greater than conformer I. Both conformers are separated by a potential barrier and, therefore, can exist simultaneously in a certain temperature range. Perhaps torsional vibrations of hydroxyl groups are of greatest interest in this molecule. In accordance with calculation results, due to the presence of symmetry, torsional vibrations of two O-H groups form symmetric and antisymmetric modes. Kinematic and force interaction between torsion coordinates is significantly smaller in conformer I. As a result, frequencies of symmetric and antisymmetric vibrations turn out to be very close (369 and 356 cm^{-1} , respectively). A different picture takes place in case of second conformer, where frequencies of corresponding vibrations are equal to 156 and 375 cm^{-1} . Frequencies of the remaining vibrations, including those calculated in anharmonic approximation, are also analyzed in this work.

EXPERIMENTAL ASSESSMENT OF ABSORBED PULSE ENERGY VIA TIME RESOLVED DIGITAL HOLOGRAPHY

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In order to correlate damaging laser fluence with the pertinent theoretical considerations, there were many attempts in to establish reliable damage predicting criterion. For example, reaching a critical property of material such as - temperature (melting point), - thermoelastic stress [1], - electron density [2]. However, there are no physical restrictions for critical stress damage without critical electron density and vice versa. Fundamentally, absorbed energy density is better suited candidate for universal damage criteria as a common denominator for all critical processes [3]. However, its reliable experimental evaluation is a non-trivial task. To our best knowledge, it was never estimated experimentally in the vicinity of the damaging fluence of optical materials. In this study, we present a novel approach based on well-established pump-probe digital holographic microscopy. This technique enables recording of time-dependent single-shot induced thermal lens in fused silica excited at fluence levels above the damage threshold and constructing a detailed picture of the dissipation of nonlinearly absorbed optical energy. In a case study of fused silica glass with infrared laser pulses at 1030 nm central wavelength and 450 fs pulse duration we found that material modification started to occur when the sample absorbed more than 10% of incident energy, while the absorbance above 15% resulted in catastrophic damage.

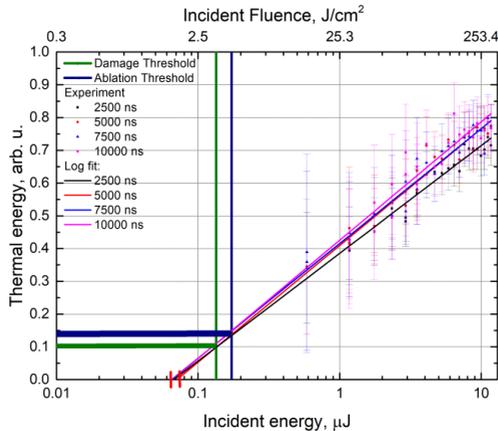


Fig. 1. The absorbed thermal energy as a fraction of incident energy, measured at different time delays in fused quartz, for three pump energies. Red bars - extrapolated thermal energy absorption threshold.

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PROPERTIES OF TERAHERTZ WAVE GENERATED BY LASER INDUCED AIR PLASMA

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Currently due to many applications in imaging and spectroscopy, terahertz (THz) radiation is a subject of great interest. One of the most efficient methods of creating very strong electric fields of THz radiation is using bichromatic femtosecond laser pulses consisting of the first and second harmonics (FH and SH, respectively) to create a plasma filament where THz pulses are emitted [1, 2]. In this research we examine polarization of THz wave as a function of polarizations of FH and SH and found conditions for the most efficient THz radiation generation. In addition, we have also conducted experiments studying properties of THz signal (modulation of intensity and azimuthal phase), emitted from laser induced plasma in air, when the SH pump was carrying an optical vortex charge. For the experiments we have used a Ti:sapphire laser system (Legend elite duo HE+, Coherent Inc.), delivering pulses with duration of 40fs (FWHM), central wavelength of 800nm and a repetition rate of 1 kHz.

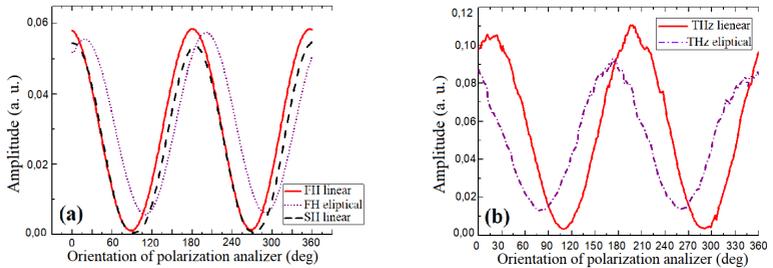


Fig. 1. (a) - FH and SH wave signal dependencies on orientation of analyzer; (b) - THz wave signal versus orientation of the analyzer for different ellipticities of the THz wave.

In the first experiment we used a Glan prism as an analyzer to monitor polarizations of FH and SH, and a quarter-wave plate to change ellipticity of these waves. By measuring amplitude ratios between the peak and minimum points (fig. 1(b)) it was found that THz frequency radiation has a higher ellipticity of polarization than that of the pump (fig. 1(a)). We deduced that THz wave polarization depends on angle between linearly polarized pump beams as well as ellipticities of FH and SH beams. Making pump polarizations parallel to each other not only increased THz signal but also decreased ellipticity of THz wave. When polarizations of FH and SH were slightly elliptical (1:10 and 1:122 for the FH and SH, respectively), THz ellipticity was higher, 1:7. This ratio increased to 1:25 after changing ellipticities of FH and SH to 1:58 and 1:122.

In the second experiment we used s-waveplate in order to generate an optical vortex in the SH beam. FH beam remained Gaussian. Using method of THz wave generation from air plasma, radiation is being generated in a conical shape [3] thus, no significant change in beam shape is being observed when changing shape of a pump beam. We used a thermographic camera to observe THz signal spatial distribution. To estimate azimuthal phase distribution of the THz wave we used a Mickelson interferometer or a cylindrical mirror. We have compared THz beam profiles obtained under two different generation conditions: when there was an optical vortex charge in one of the excitation beams; and when both pump beams were Gaussian. We have found that when SH is an optical vortex, THz radiation also carries some properties of optical vortex which was found by examining its intensity distributions in focal plane of the cylindrical mirror, as well as by observing shifts of fringes in the THz interferogram.

Therefore we investigated THz wave polarization dependence on pump wave polarizations; and THz signal when there is an azimuthal phase modulation of one of pump beams. We believe that the presented investigations will open new routes towards an active control of ultra-broadband THz beam properties.

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Ab initio multi-reference perturbation theory studies on the LiRb and KCs molecules and transport properties of some alkali metals media

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The recent developments in production of ultracold diatomic molecules containing alkali metal atoms have revealed their unique properties giving the ability to be used in various fields: creation of a Bose-Einstein condensate; quantum information processing; testing fundamental laws of physics by precision spectroscopy measurements; in controlled chemical reactions and etc. [1]. For the applications mentioned one needs to produce such molecules in the absolute ground state. Thus the knowledge about the ground and low-lying electronic states, spectral and other properties of ultracold diatomic molecules are crucial for potential use, which can be obtained by series of experiments or by performing *ab initio* quantum-chemical calculations and applying appropriate molecular theories. The diatomic polar LiRb and KCs molecules are a typical examples of ultracold molecules under comprehensive study.

In this study, the SA-CASSCF/XMCQDPT2 calculations of the low-lying singlet and triplet states of the LiRb and KCs molecules are performed with (4,10) and (6,8) active space respectively. The TZ-basis sets and Stuttgart RSC ECP (for Rb, Cs and K atom) have been used in calculations. The calculations have been carried out pointwise in two stages in the wide range of internuclear distances for both molecules. The results of our calculations of the spectroscopic parameters of the LiRb's ground state $X^1\Sigma^+$ ($R_e = 3.4508 \text{ \AA}$, $D_e = 5926.7 \text{ cm}^{-1}$) very well agree with experimental data ($R_e = 3.4661 \text{ \AA}$, $D_e = 5927.9 \text{ cm}^{-1}$ [2]). The spectroscopic parameters of the KCs's ground state $X^1\Sigma^+$ ($R_e = 4.2781 \text{ \AA}$, $D_e = 4070.3 \text{ cm}^{-1}$) also exactly coincide with experimental data ($R_e = 4.2838 \text{ \AA}$, $D_e = 4069.2 \text{ cm}^{-1}$ [3]). These results exhibit the best agreement among all previously performed for LiRb and KCs molecules *ab initio* calculations.

On the basis of the kinetic theory of gases and calculated potentials for the ground state the transport properties of a diluted two-component Li-Rb and K-Cs gases were defined. At first stage the extrapolation of the potential into the region of small internuclear distances was made. Then the reduced collision integrals were evaluated, through which coefficients of diffusion, viscosity and thermal conductivity are determined. These transport properties are obtained as functions of pressure and temperature.

This work was supported by State Committee on Science and Technology of the Republic of Belarus.

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Femtosecond optical parametric oscillator synchronously pumped by Yb:KGW laser and based on periodically poled potassium titanyl phosphate crystal

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Synchronously pumped optical parametric oscillators (SPOPO) are used as sources of tunable coherent radiation working at high repetition rate. Near and mid-IR radiation of such devices are desirable in many fields of applications: nonlinear microscopy, spectroscopy, gas sensing, etc. [1]. Ti:sapphire laser as a pump source and a periodically poled lithium niobate crystal as a nonlinear medium are the most common choices for such SPOPOs [1,2]. We present periodically poled potassium titanyl phosphate crystal (PPKTP) pumped by femtosecond Yb:KGW laser as the efficient alternative for the aforementioned appliances. The obtained efficiency of the maximum parametric light conversion to signal power was more than 37.5% at 1530 nm wavelength (Fig.1), whereas the achieved continuous tuning range of the signal was 1470 nm - 1970 nm with signal pulse durations ranging from 91 fs to 280 fs.

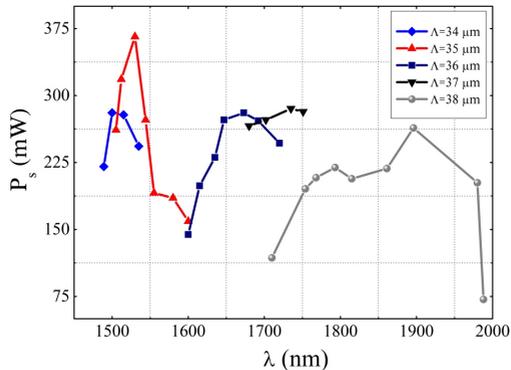


Figure 1: PPKTP SPOPO output power dependence on signal wavelength (pump power was equal to 1W).

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NONLINEAR REFRACTIVE INDEX MEASUREMENT IN THE INFRARED USING FEMTOSECOND LASER PULSES

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Nowadays the scientific research and experiments in the infrared (IR) attract a lot of interest as it is a promising area of high intensity laser physics, e.g. attosecond pulses generation [1]. However, some parameters of optical materials used in the IR, are not well known. One of the most important parameters facilitating nonlinear phenomena is nonlinear refractive index or n_2 .

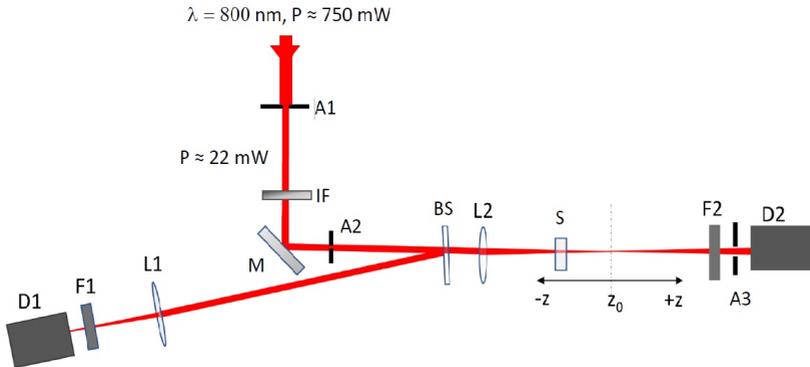
In this work, determination of nonlinear refractive index using a standard z-scan [2] technique for various samples - fused silica, sapphire and BK7 are presented. The z-scan experiment was carried-out using femtosecond laser sources at infrared wavelengths.

The z-scan technique allows to easily determine nonlinear refractive index (NLR) sign and magnitude as well as the impact of nonlinear absorption (NLA). The z-scan measurements are performed by translating the sample along the beam propagation axis and measuring the phase variation behind the aperture with a detector. A typical closed aperture z-scan shows characteristic valley-peak curve which indicates positive n_2 sign. Nonlinear refractive index is determined from phase change ($|\Delta\phi|$) which is calculated from normalized transmittance curve difference between valley and peak. (ΔT_{p-v}) (Eq. (1,2)).

$$|\Delta\phi| = \frac{\Delta T_{p-v}}{0,406(1-S)^{0,25}} \quad (1)$$

$$n_2 = \frac{\Delta\phi_0}{kl_0L_{eff}} = \left(\frac{\lambda}{2\pi}\right) \frac{\Delta\phi_0}{I_0L_{eff}} \quad (2)$$

Here S is linear transmission of an aperture, I_0 - peak intensity, L_{eff} is effective sample length. The z-scan experimental setup for evaluation of the n_2 was developed, see Fig. 1. Here S - sample, A1, A2, A3 - apertures, IF - interference filter, L1, L2 - focusing lenses, BS - beam splitter, M - metal mirror, D1, D2 - detectors, F1, F2 - neutral density filters.



1 Fig.. Experimental scheme

The investigated optical materials were translated using a motorized delay line and the whole process of signal acquisition was automated and controlled via a LabView based program. From the closed and open aperture z-scan measurements, the nonlinear refractive index for fused silica, sapphire, and BK7 were determined and compared.

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Modelling of sensors based on whispering gallery mode optical microresonators

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The whispering gallery modes (WGM) resonators are based on spherical objects, which are made from optically transparent materials. Light can't enter straight into it, so a prism or microfiber is used. When light reaches the edge of prism or microfiber, it penetrates out of it and gets inside the sphere. When light is inside the sphere, it is circling around due to total internal reflection. If there is a light source which supplies the sphere with constant intensity, the wave moving along the perimeter of the sphere starts constructively interfere. In this case, the resonance happens, which is called whispering gallery mode (WGM). When there is a change in temperature, it changes the radius of WGM resonator, and that results in a change of reflection coefficient, which results in a change of resonance and intensity. Thus WGM can be used as a temperature sensor. Similarly, the resonance changes due to other effects like moisture and wavelength. Theoretical modelling of these processes is done using COMSOL Multiphysics software with Wave Optic Module. In some cases, the model is compared with experimental data.

Acknowledgements

We thank for support for Latvian LZP Project No.Lzp-2018/1-0510 Optical whispering gallery mode microresonator sensors, and ERAF Project No. 1.1.1.1./16/A/295 Development of novel WGM microresonators for optical frequency standards and biosensors, and their characterization with a femtosecond optical frequency comb.

INVESTIGATION OF SUPERCONTINUUM GENERATION IN PHOTONIC CRYSTAL FIBER USING BURSTS OF TWO FEMTOSECOND PULSES

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A phenomenon, when spectrum of a short pulse expands hundreds or thousands of times is called supercontinuum generation. Supercontinuum generation is usually achieved by launching short high peak power pulses through a nonlinear medium. Photonic crystal fibers (PCF) are often used as a nonlinear medium for generation of supercontinuum due to ability to engineer the PCF dispersion, high nonlinearity and unique waveguide properties. The use of PCFs for supercontinuum generation enabled its use in spectroscopy, frequency metrology, optical coherence tomography, etc. [1-2]. Typically, a continuous train of ultrashort pulses are used as a pump for supercontinuum generation.

In this report we present experimental results of our investigation of supercontinuum generation in photonic crystal fiber using bursts of two femtosecond pulses. Femtosecond Yb:KGW laser oscillator generating 1030 nm wavelength 76 MHz repetition rate and 90 fs duration pulses was used as a pump for supercontinuum generation. A setup using a beamsplitter and a Brewster-type polarizer was used to create a burst of two pulses. Due to use of a polarizer, the burst consisted of two orthogonal polarization pulses which were directed to the PCF. For supercontinuum generation, we used a 27.6 cm long polarization-maintaining highly nonlinear PCF, which had core diameter of $1.8 \pm 0.3 \mu\text{m}$ and average pitch of $1.19 \pm 0.3 \mu\text{m}$. The PCF zero group velocity dispersion wavelengths for slow polarization mode are at $807 \pm 2 \text{ nm}$ and $1040 \pm 7 \text{ nm}$, whereas for fast polarization mode they are at $838 \pm 2 \text{ nm}$ and $1059 \pm 9 \text{ nm}$. During the experiment, we adjusted the energy ratio between the horizontal and vertical polarization beams. While changing the temporal delay of the vertical polarization pulse in the burst with respect to the horizontal polarization pulse in the burst, spectra of the generated supercontinuum of both orthogonal polarization modes were measured. The measurements of supercontinuum spectra were performed with different pumping power.

The generated supercontinuum spectrum extended from roughly 510 nm to 1300 nm. Aggregated spectra of supercontinuum generation in visible and infrared wavelength range, when power of the vertical polarization pulse in the burst were at its maximum and equal to 800 mW are shown in Fig 1. The results show that different polarization pulses effectively interact in the region of zero delay because they are matched in time. Furthermore, when temporal delay between pulses in the burst is zero, the aggregated supercontinuum spectrum is widest. It is also evident that the interaction between pulses with different polarization occurs even when the power of horizontal polarization pulse is very small.

This study is partially supported by the Lithuanian Research Council (LMT).

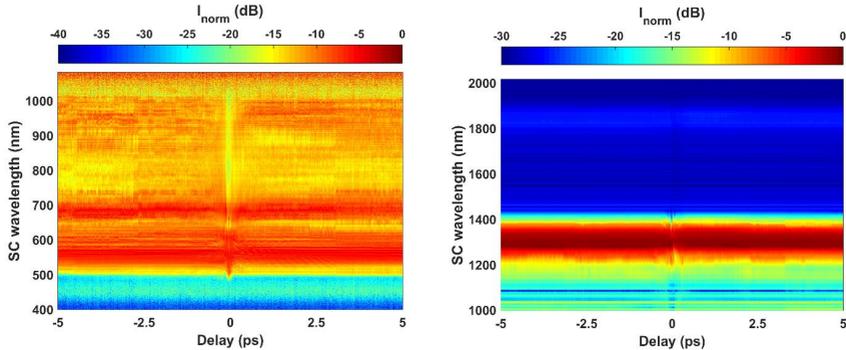


Fig. 1. Spectrograms of supercontinuum generation in visible (left) and infrared (right) wavelength range when power of vertical polarization pulse in the burst is $P_v = 800 \text{ mW}$ and power of horizontal polarization pulse in the burst is $P_h = 800 \text{ mW}$.

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Optical properties and amplified spontaneous emission of new synthesised glass forming pyranlyden derivatives

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Motivation

Organic molecule 6-(tert-butyl)-4H-pyran-4-ylidene malononitrile (DCM) is one of the most used laser dye as a component in light amplifying medium [1,2]. The main drawback of DCM is its crystallization which reduce optical properties of the light amplifying system. To overcome this issue 12 original glass forming pyranlyden derivatives were investigated. The difference between the compounds is acceptor group and bulky group that prevents compound from crystallization. (see Fig. 1).

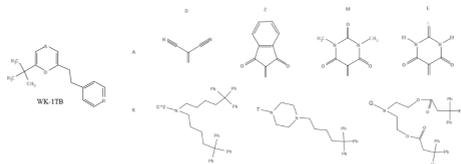


Figure 1: Chemical structures of the investigated dyes.

Methods

Few hundred nanometer thin films from dichloromethane solution were prepared with spin coating method and its absorption spectra, amplified spontaneous emission (ASE) and photoluminescence quantum yield were measured. ASE was measured with the variable stripe length technique [3] and the excitation wavelength for each sample is the same as the wavelength of absorption maximum for the particular compound.

Conclusions

Amplified spontaneous emission was observed in all of investigated compounds therefore shows potential for application in the organic solid-state lasers. Compounds with the attached triphenyl group via ester group showed the lowest ASE excitation threshold energy values. Additionally 1,3-dimethylpyrimidine-2,4,6(1H,3H,5H)-trione as electron acceptor group improved ASE properties. Overall the best compound is MWK-1TBQ with ASE excitation threshold energy value of $15 \mu\text{J}/\text{cm}^2$. More detailed analysis of the impact of compound groups on light properties will be discussed.

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Study of the functional composition of detonation diamonds and stability of the spectral properties of their aqueous suspensions

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The field of research presented in this abstract is the properties of ultrafine diamonds. DND - are an emerging class of nanocarbon that is find numerous industrial applications that range from additives in lubricating oil to polymer composites.[1] Diamond nanoparticles occupy a special place of nanomaterials due to their combination of outstanding mechanical performance, chemical resistance, biocompatibility, and unique optical and electronic properties. Due to their small size with typical diameter ranging from 5 to 10 nm, it is important to understand their behavior and movement in different environments especially water neder. To realize its potential, precise control of the ND structure and physical properties is required. For the purpose of change of functional structure of a surface of particles of DND in this study was made heat treatment nanodiamonds mark UDA-SP (Minsk). At the same time control was carried out by means of analysis absorption IR ranges.The stability of the spectral properties of aqueous suspensions based on DND subjected to various temperature treatment was studied.As a result of the conducted research it was revealed All types of temperature processing affect behavior DND in the water environment.

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Comprehensive spectral (FT-IR, Raman, UV/Vis) and theoretical (DFT, TDDFT, MRPT, biological activities) studies of adamantane-based compounds, promising for medicinal chemistry

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The adamantyl moiety was recognized as an essential fragment in various pharmacologically active drugs. Adamantane derivatives possess antiviral activity against Influenza A virus and HIV, as well as, anti-microbial, anti-inflammatory and anti-proliferative activities. It is also known that adamantyl group changes the properties of known drugs or provides an important pharmacophore for the design of new drugs [1].

In this study, the structures and spectral properties (IR, Raman and UV/Vis spectra) of adamantane-based derivatives, namely ethyl 4-[3-(adamantan-1-yl)-4-phenyl-5-sulfanylidene-4,5-dihydro-1H-1,2,4-triazol-1-yl]methylpiperazine-1-carboxylate (compound I), (Z)-3-(adamantan-1-yl)-1-(3-chlorophenyl)-S-benzyl-isothioureia (compound II), N-(adamantan-1-yl)-4-phenylpiperazine-1-carbothioamide (compound III), 1-(adamantan-1-yl)-3-(3-chlorophenyl)thioureia (compound IV) and N¹-(adamantan-2-ylidene)-R-hydrazides, where R = thiophene-2-carbo-, adamantan-1-, benzo-, and pyridine-5-, (compounds V-VIII) have been obtained at the DFT (B3LYP/cc-pVTZ) and Multi-Reference Perturbation Theory (SA-CASSCF/XMCQDPT2) levels of theory calculations. The biological activities were predicted on the basis of compound structural data.

Firstly, conformation analysis has been carried out for the all compounds. We found two (compound I), three (II), two (III), four (IV) and four (V-VIII) stable conformers. Compounds (V-VIII) are combined in one group as they demonstrate existence of particular stable conformers: two "regular" trans- and cis-conformers and two "side" trans-conformers.

The UV/Vis spectra of solution of the compounds in ethanol were measured in the range of 450-200 nm. The UV/Vis spectra simulations at the Time-Dependent DFT and Multi-Reference Perturbation Theory levels of theory demonstrate unsuitability of the TDDFT for description of the experimental spectra of the compounds. It is highly probable that this is a consequence of the intramolecular charge transfer (ICT). In contrast, the MRPT results are in a good agreement with the experimental spectra. The functional groups of the compounds having donor and acceptor properties and taking part in ICT have been determined on the basis of Mulliken and Löwdin atomic populations analysis.

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Experimental studies of laser power influence on circularly polarised laser-induced fluorescence component dependence on an external magnetic field for the $F_g=2 \rightarrow F_e=3$ transition of ^{85}Rb $D1$ line

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Recent developments of extremely precise optical magnetometers have proved the validity of experiments on magneto-optical effects. This study builds on previous work [1], where the coherent and incoherent effects were studied in the excited state of rubidium atoms.

The aim of this work was to explore the phenomena of ground-state angular momentum conversion from alignment, created by linearly polarized laser radiation, to orientation due to a changing external magnetic field in ^{85}Rb atoms. This was done by observing two oppositely circularly polarised light components of laser-induced fluorescence (LIF) in a vapour cell; the $F_g=2 \rightarrow F_e=3$ transition of $D1$ line was chosen for this work. We studied the influence of laser power on the signal as well as on the differences of the two oppositely circularly polarized LIF components. The registered LIF signal was compared to theoretical data that were calculated using a theoretical model developed in the Laser Centre [2]. A good experiment-and-theory agreement was achieved for all the laser powers examined.

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Use of spectroscopy for the detection of aromatic compounds after processing with microorganisms of the fungi kingdom

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One of the major problems in modern society is environmental pollution with polycyclic aromatic hydrocarbons. Polycyclic aromatic hydrocarbons (PAH) like carbazole and phenothiazine are one of the well known environmental pollutants that threaten our health. The chemical and mechanical methods for PAH removal have limited effectiveness and can be very expensive. In this case bioremediation is a cheap and effective solution as it functions on biodegradation. The microorganisms help recycle nutrients as well as various organic compounds through ecosystems. In order to reduce the contamination, the advantage of fungi kingdom microorganisms like yeast degrading properties was taken.

Various experiments were carried out in order to determine whether aromatic compounds like carbazole and phenothiazine have influence over the yeast growth and whether the yeast are able to degrade PAC compounds that are present in contaminated soil. The aim is to determine whether an UV spectroscopy is a useful method to evaluate the ability of yeast to degrade polycyclic aromatic compounds. The dependence of the effect of yeast on the growth of the plant from the organic pollutant concentration in the soil was determined.

Multi-dimensionality effect on 2D Hamiltonian model of methyl hydroperoxide

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Both characterization and spectroscopic identification of the molecule of methyl hydroperoxide (MHP) in the air and interstellar medium requires knowledge of its fundamental (ab initio) parameters [1].

The more atoms (N) consists a molecule, the more models of the multi-dimensional ones appear together with the data discrepancies [1, 2]. Therefore the aim of the present work is to kickoff a basis analysis of the discrepancies to reveal the express-criteria of the reliability of so-called 2D model by the applying of the ab initio TNum package [3].

The model reduces a ND Hamiltonian to 2D one and adjusts it to the molecule of MHP that has two tops — the hydroxyl and the methyl ligands. The tops can undergo an internal rotation. The model postulates activity of only these two internal coordinates whereas applies geometry optimization to all the rest ones.

To monitor the model behaviour one calculates the parameters of kinetic energy operator at more than 14000 nodes for the models from 2D to 15D. Table 1 proves the validity of the approach. Figure 1 reveals strong dependency of ones on the model dimensionality and explains the discrepancy origin. At this, only the hydroxyl top's parameter $f_2(11)$ predicts a substantiation of theoretical 2D model while practical involving its ND realization.

Table 1: Kinetic energy operator parameters for the equilibrium geometry [1]

Symbol, Unit	Value [1]	Symbol	Unit	Value · 10 ⁵ [PW]	Unit	Value [PW]
B ₁ , cm ⁻¹	6.702	f ₂₂₂	Hartree	-3.4239380	cm ⁻¹	-7.515
B ₂ , cm ⁻¹	21.443	f ₂₁₁	Hartree	-9.4175943	cm ⁻¹	-20.669
B ₁₂ , cm ⁻¹	-1.166	f ₂₁₂	Hartree	0.9173566	cm ⁻¹	2.013
		f ₁₁	Hartree	0.0472952	cm ⁻¹	0.104
		f ₁₂	Hartree	-0.3135577	cm ⁻¹	-0.688

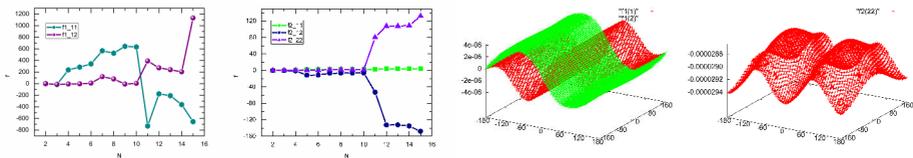


Figure 1: Kinetic energy operator parameters.

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