18th International Young Scientist Conference **"Developments in Optics and Communications 2022"**

ABSTRACT BOOK

Optical Materials and Phenomena

Laser Physics and Spectroscopy

Communications

Biophotonics

Vision Science

DEVELOPMENTS in Optics and Communications 2022

April 21-22

WWW.DOCRIGA.LV

SPIE. STUDENT CHAPTER UNIVERSITY OF LATVIA

UNIVERSITY OF LATVIA

UNIVERSITY OF LATVIA
INSTITUTE OF ATOMIC PHYSICS AND SPECTROSCOPY

DOC 2022 Abstract Book

18th International Young Scientist conference
Developments in Optics and Communications 2022

Editor: Inga Brice
Institute of Atomic Physics and Spectroscopy
University of Latvia
Jelgavas street 3, Riga, LV1004, Latvia

ISBN 978-9934-23-624-2

Cover design: Inga Brice

www.docriga.lv

Welcome

Dear participants of **DOC 2022**,

Our traditional DOC conference is organized once more in online format with Zoom meetings and poster sessions in Gather Town. The purpose of this conference is to bring together students and young scientists working experimentally and theoretically in fields of optics and photonics to share and exchange new ideas and to establish contacts for future collaboration. We hope that next year we will meet in person and we will be able to share our great ideas here in Riga.

"*Learn continually – there's always* ***"one more thing"*** *to learn.*" – Steve Jobs

We wish You to learn at least one small thing during this conference, whether it is about microresonator-based optical frequency combs, confocal videomicroscopy or how to prepare the best presentation and poster, it's up to You!

Best regards,
DOC 2022 Organizers

The Organizing Committee

DOC chairs

- Ilze Oshina
  PhD student, researcher
  University of Latvia
- Inga Brice
  researcher
  University of Latvia

Organizers

- Zane Jansone-Langina
- Kristine Kalnica Dorosenko
- Tatjana Pladere
- Kristians Draguns

Scientific committee

- Prof. Ruvin Ferber
  Faculty of Physics and Mathematics, University of Latvia
- Dr. Varis Karitans
  Department of Optometry and Vision science, University of Latvia
- Prof. Uldis Rogulis
  Institute of Solid State Physics, University of Latvia
- Prof. Janis Spigulis
  Institute of Atomic Physics and Spectroscopy, University of Latvia

Contents

Invited Speakers

Talks

Laser Physics and Spectroscopy

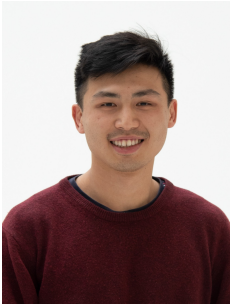
Poster Session 1

Part I
Invited Speakers

Microresonator-based Optical Frequency Combs

Bi Toby[1,2]

[1] *Max Planck Institute for the Science of Light, 91058 Erlangen, Germany*
[2] *Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany*



The discovery and development of optical frequency combs (OFCs) enabled the precise measurement of the frequency and phase of optical signals. In the frequency domain, an optical frequency comb comprises of sharp, equally-spaced components that have low phase noise between each other. By harnessing the equidistant frequency component accuracy and stability, OFCs can act as a highly accurate ruler. In fact, the initial purpose of OFCs was to measure the atomic frequency transitions up to a resolution of 18 digits [1].

The first demonstration of OFC came in the form of mode-locked lasers where multiple longitudinal modes inside the laser cavity coherently interfere at the output. The large number of longitudinal modes naturally leads to many frequency components or "comb lines" providing both the advantage of accuracy and broad optical bandwidth. The use of mode-locked lasers increased both the space and time efficiency of frequency measurements. Since the original discovery in the 2000s [2, 3], OFCs have experienced rapid integration into many fields such as metrology [4], molecular spectroscopy [5], spectrograph calibration [6], optical communications [7] and optical ranging [8].

A few years after the generation of OFCs in mode-locked lasers, OFCs were generated in optical microresonators [9, 10]. Due to their small mode volume and low loss, microresonators are ideal candidates for nonlinear optical processes. Frequency combs based on microresonators, dubbed "microcombs", are formed via a nonlinear frequency conversion process of a single frequency input light into many frequency components. Microcombs constitute a growing interest in the miniaturisation of optical devices to increase their widespread adoption rate.

References

[1] Rosenband, T. et al. Frequency ratio of Al+ and Hg+ single-ion optical clocks; metrology at the 17th decimal place. Science 319, 1808–1812 (2008).

[2] Holzwarth, R. et al. Optical Frequency Synthesizer for Precision Spectroscopy. Phys. Rev. Lett. 85, 2264–2267 (2000).

[3] Jones, D. J. et al. Carrier-Envelope Phase Control of Femtosecond Mode-Locked Lasers and Direct Optical Frequency Synthesis. Science 288, 635–639 (2000).

[4] Diddams, S. A.et al. An optical clock based on a single trapped 199Hg ion. Science 293, 825–828 (2001).

[5] Yu, M. et al. Gas-phase microresonator-based comb spectroscopy without an external pump

laser. ACS Photonics 5, 2780–2785 (2018).
[6] Obrzud, E. et al. A microphotonic astrocomb. Nat. Photonics 13, 31–35 (2018).
[7] Marin-Palomo, P. et al. Microresonator-based solitons for massively parallel coherent optical communications. Nature 546, 274–279 (2017).
[8] Kuse, N. & Fermann, M. E. Frequency-modulated comb LIDAR. APL Photonics 4, 106105/1–7 (2019).
[9] Del'Haye, P. et al. Optical frequency comb generation from a monolithic microresonator. Nature 450, 1214–1217 (2007).
[10] Savchenkov, A. A. et al. Tunable optical frequency comb with a crystalline whispering gallery mode resonator. Phys. Rev. Lett. 101, 093902 (2008).

A mechanoluminescence based approach to spatial mechanical stress visualisation in 3D printed parts

Vitola Viriginija
Institute of Solid State Physics, University of Latvia
E-mail: Virginija.Vitola@cfi.lu.lv

3D printing is a rapidly developing technology that is already being utilized for the manufacture of mechanical parts in a variety of industries, including manufacturing, transportation, healthcare, construction, electronics, aerospace, and the development of new and improved sensors. Stress analysis and simulation is one of the most critical processes in part design for numerous applications. Although numerical analysis, such as with COMSOL, can provide a simulated approach to the stress distribution in mechanical parts, there are frequently significant imprecisions due to model and real-world discrepancies. This talk will outline a method for a modification of precise and versatile 3D printing technology, mechanoluminescence measurements and method of data processing to satisfy the need for easy and non-destructible spatial stress analysis on 3D printed mechanical parts.

Visual challenges and benefits in the world of XR-displays

Svarverud Ellen

National Centre for Optics, Vision and Eye Care, Faculty of Health and Social Sciences, University of South-Eastern Norway

** E-mail: Ellen.Svarverud@usn.no*

XR (eXtended Reality) technologies such as VR (Virtual Reality) and AR (Augmented Reality) have become increasingly commonplace. This is exciting from a visual function perspective because people have to rely on their vision when using 3D XR technologies. We know that having two good and cooperating eyes is necessary to take full advantage of using these technologies, which means that it is imperative to have fully functional stereo vision, good oculomotor control and corrected refractive errors. Further, in 3D displays, the visual system has to work differently from in the physical world, because the neurological link between vergence and accommodation is broken (vergence-accommodation conflict). Many studies have shown how visual cues can be used and manipulated in all types of visual displays, demonstrating how important it is to understand vision for optimal utilization of XR technologies. Nevertheless, not many papers on utilization and usage of XR technologies have acknowledged that the person's vision and potential vision problems affect comfort, performance and the ability to work over longer time periods. As these technologies continue to be more widespread, it is important for optometrists and vision scientists to understand what challenges and benefits XR displays pose for the visual system.

Light-based technologies for clinical impact: hyperspectral imaging and reflectance confocal videomicroscopy of skin

Saknite Inga, Patrinely J. Randall , Zhao Zijun, Kwun Shinwho, Zhang Kathy, Hood Alexis, Chen Fuyao, Kangas Lauri, Kukkonen Ari, Kortteisto Pirjo, Kim Tae Kon, Beeghly-Fadiel Alicia , Byrne Michael, Spigulis Janis, Tkaczyk Eric R.

Accurate diagnosis and tracking of active inflammation or erythema remains a challenge in a variety of inflammatory skin diseases, especially in the setting of natural and pathological pigment. Treatment decisions rely on the determination whether disease is stable or progressing. Visual assessment is subjective, and digital photography has a limited spectral sensitivity to clearly distinguish skin absorbers of interest. Here we present the feasibility of hyperspectral imaging in the visible spectral range to identify and segment erythema and pigment. We studied patients with a severe complication of the skin after a stem cell transplant. Additionally, we explore skin inflammation as the motion of individual immune cells in upper dermal microvessels by reflectance confocal videomicroscopy and report robust survival associations of a novel biomarker.

Acknowledgement
This work was supported by a Career Development Award from the United States Department of Veterans Affairs Clinical Sciences R&D Service (IK2 CX001785), the Vanderbilt University Medical Center Department of Medicine, the National Institutes of Health (K12 CA090625), and the European Regional Development Fund (1.1.1.2/VIAA/4/20/665).

Part II
Talks

Geometry optimization and soliton comb formation inside whispering gallery mode resonators

Draguns Kristians[1], Atvars Aigars[2], Veilande Rita[1], Alnis Janis[1]
[1] *Institute of Atomic Physics and Spectroscopy, University of Latvia*
[2] *Institute of Astronomy, University of Latvia*
[*] *E-mail:* kristians.draguns@lu.lv

A soliton is a self-reinforcing wave packet that maintains its shape and propagates at a constant velocity. Whispering gallery mode resonators (WGMRs) are small optically transparent objects, where light is confined with the total internal reflection. When a high Q resonator is pumped with a sufficiently powerful laser, various nonlinear effects take place, including four-wave mixing, that generates photons with new frequencies. Only resonant frequencies get amplified, generating an equidistant frequency comb. Soliton combs are formed only at a double balance of the parametric gain and resonator loss on the one hand and Kerr nonlinearity and dispersion on the other [1]. When such double balance is achieved, different resonating frequencies all travel around the resonator together in a wave packet, generating pulses. The dispersion of the resonator is reliant on the material and geometry of the resonator and can be optimised by changing the shape of the resonator and finding a corresponding dispersion curve, where the pumping laser wavelength is on the local maximum of the dispersion curve and inside anomalous dispersion region.

Acknowledgment
This research was funded by the European Regional Development Fund Project No. 1.1.1.1/18/A/155 and the European Social Fund Project No. 8.2.2.0/20/I/006.

References
[1] Herr, T., Brasch, V., Jost, J. D., Wang, C. Y., Kondratiev, N. M., Gorodetsky, M. L., & Kippenberg, T. J. (2014). Temporal solitons in optical microresonators. Nature Photonics, 8(2), 145–152. https://doi.org/10.1038/nphoton.2013.343

3D magnetometry based on atomic alignment in cesium vapor

Osite Dace[1,*], Gahbauer Florian[1], Busaite Laima[1], Mozers Arturs[1], Auzinsh Marcis[1]
[1] *Laser Centre, University of Latvia, Rainis Boulevard 19, LV-1586 Riga, Latvia*
[*] *E-mail:* dace.osite@gmail.com

Measurement of small magnetic fields are useful and necessary in many different fields. Through a process called optical pumping, the distribution of angular momenta in an atomic vapor manipulated with laser radiation in such a way that the vapor's optical properties become very sensitive to magnetic fields. Such optically pumped magnetometers (OPMs) have seen rapid advances in recent years. Along with new scientific achievements, the sensitivity of optically pumped magnetometers (OPM) has greatly improved and is now comparable to high sensitivity magnetometers such as those based on superconducting quantum intereference devices (SQUIDs)[1][2], which require cryogenic temperatures to operate. Oftentimes, OPMs work based on atomic angular momentum orientation, but using similar principles they can also work based on atomic alignment.

In this work we study the theoretical absorption signals that could be observed when applying an external magnetic field to an aligned population of atoms in a Cesium vapor cell.

In the proposed experimental setup, the atoms are excited to an aligned state by a pump beam. When an external magnetic field is applied, the aligned state starts to precess in the plane perpendicular to the applied magnetic field. Absorption signals are obtained using a probe beam. Using an electro-optical modulator, we can switch between two polarization states of the probe beam. Therefore, two of the magnetic field components can be measured using the same probe beam. To measure the third magnetic field component, we plan to add radiofrequency coils to the experimental setup.

The respective theoretical results show that there is a distinctive absorption signal dependence on the magnetic field. This means the suggested experimental setup could yield successful results in measuring the components of the magnetic field.

References

[1] V. Shah, G. Vasilakis, and M. V. Romalis, Phys. Rev. Lett. 104, 13601 (2010).
[2] J. C. Allred, R. N. Lyman, T. W. Kornack, and M. V. Romalis, Phys. Rev. Lett. 89, 1308011 (2002).

Experimental Investigation of the Hyperfine Structure of Tm I with Fourier Transform Spectroscopy in the Visible Wavelength Range

Parlatan Seyma[1,*], Ozturk Ipek Kanat[2], Basar Gonul[2], Basar Gunay [3], Ferber Ruvin [4], Kroger Sophie[5]

[1] *Istinye University, Vocational School of Health Services, Istanbul, Turkey*
[2] *Istanbul University, Faculty of Science, Physics Department, TR-34134 Vezneciler, Istanbul, Turkey*
[3] *Istanbul Technical University, Faculty of Science and Letters, Physics Engineering Department, TR-34469 Maslak, Istanbul, Turkey*
[4] *Laser Centre, University of Latvia, Jelgavas Street 3, LV-1004 Riga, Latvia*
[5] *Hochschule für Technik und Wirtschaft Berlin, Wilhelminenhofstr. 75A, Berlin D-12459, Germany*
[*] *E-mail:* seyma.parlatan@istinye.edu.tr

The aim of the present study is to provide further experimental data on the hyperfine structure (hfs) of atomic thulium (Tm). The lanthanide Tm is one of the very few elements that have only one stable isotope. The nuclear spin of this isotope, ^{169}Tm, is I=1/2. As a consequence, only magnetic dipole hfs is observed in Tm spectra.

Spectroscopic data of heavy elements are required for example for astrophysical purposes. The hfs of atomic Tm has been studied experimentally by several authors (see [1] and references therein). However, there are still many hfs constants waiting to be measured.

The spectra of a thulium hollow cathode discharge lamp have been measured with a Fourier Transform spectrometer in the visible wavelength region from 400 nm to 700 nm. For the measurements a high-resolution Bruker IFS 125 HR FT spectrometer at the Laser Centre of the University of Latvia in Riga has been used.

The hfs of 50 selected spectral lines is investigated. Only spectral lines with two clearly separated main peaks were considered. Attention was paid to the fact that the magnetic dipole hfs constant A belonging to one of the two energy levels of the transition was known from the literature. The set of spectral lines was chosen so that the unknown hfs constant A for an energy level could be obtained from at least two lines.

As a result, the magnetic dipole hyperfine structure constant A for 20 fine structure levels of atomic Tm were determined for the first time.

Acknowledgment

R. Ferber acknowledges support from the Latvian Council of Science Project No. lzp-2020/1-0088.

References

[1] Basar G., Basar G., Ozturk I K, Acar F.G. and Kroger S., 2005 Phys. Scr. 71 159.

Infrared Fourier Transform Spectroscopy of Atomic Thulium used for Investigation of the Hyperfine Structure

Kebapci Taha Yusuf[1,*], Sert Sami [2], Parlatan Seyma[3], Kanat Ozturk Ipek [4], Basar Gonul [4], Basar Gunay [5], Tamanis Maris [6], Kroger Sophie [7]

[1] *Pamukkale University Kinikli Campus, Denizli Health Services Vocational School of Higher Education, D Block TR-20070 Kınıklı, Denizli, Turkey*

[2] *Graduate School of Engineering and Sciences, Istanbul University, TR-34452 Beyazit, Istanbul, Turkey*

[3] *Istinye University, Vocational School of Health Services, Istanbul, Turkey*

[4] *Istanbul University, Faculty of Science, Physics Department, TR-34134 Vezneciler, Istanbul, Turkey*

[5] *Istanbul Technical University, Faculty of Science and Letters, Physics Engineering Department, TR-34469 Maslak, Istanbul, Turkey*

[6] *Laser Centre, University of Latvia, Jelgavas Street 3, LV-1004 Riga, Latvia*

[7] *Hochschule für Technik und Wirtschaft Berlin, Wilhelminenhofstr. 75A, Berlin D-12459, Germany*

[*] *E-mail:* tkebapci@pau.edu.tr

With the present study, the database on the hyperfine structure of the lanthanide thulium (Tm) should be further expanded, which among other things represents an important basis for astrophysical investigations. The only stable isotope of Tm, ^{169}Tm, has a very small nuclear spin (I=1/2), which results in a very simple hyperfine structure (hfs) for this element.

Although the hfs of atomic Tm has been researched for many decades (see for example [1] and references therein), the hfs database for this element is still far away from been complete.

In this study, we investigated the hfs of 43 spectral lines of atomic Tm, measured by Fourier transform spectroscopy in the wavelength range from 700 nm to 2250 nm. The free and excited thulium atoms were generated in liquid nitrogen cooled a hollow cathode lamp.

As a result of this investigation, magnetic dipole hfs constant A of 17 fine structure levels have been determined experimentally, 14 of them for the first time. Revised values were determined for three magnetic dipole hfs constants already mentioned in the literature [1,2,3]. The revised values are completely different from the previous values.

Acknowledgment

M. Tamanis acknowledges support from the Latvian Council of Science Project No. lzp-2020/1-0088.

References

[1] Basar G., Basar G., Ozturk I K, Acar F.G. and Kroger S., 2005 Phys. Scr. 71 159.
[2] J. Kruger 1986 Diploma Thesis. Diploma Thesis (Bonn, Germany).
[3] Zhou Z, Zhu L, Jing C, Zhang S and Lin F 1993 Acta Optica Sinica 1993 673.

Photovoltage Formation Across GaAs P-N Junction Under Intense Laser Light

Masalskyi Oleksandr[1,*], Gradauskas Jonas[1], Zharchenko Ihor[2]
[1] *Vilnius Gediminas Technical University, Lithuania*
[2] *Center for Physical sciences and Technology, Lithuania*
[*] *E-mail:* oleksandr.masalskyi@vilniustech.lt

The Shockley-Queisser theory defines possible maximum efficiency of a single junction solar cell under illumination of one AM 1.5 G spectrum standard sun [1]. The theory is based on statement that only photons with energy equal or higher than the band gap of a semiconductor can generate an electron-hole pair, and photons with energy less than the band gap are not involved in the formation of the solar cells‘ photoresponse.

Our investigation is based on assumption that the hot carrier phenomenon should be accounted in photovoltage formation across a solar cell before the thermalisation process. Photons with energy less than a semiconductor band gap as well as those with high energy do participate in the carrier heating. Calculations reveal that, in case of GaAs, 33.0% of the total AM 1.5 G solar radiation can be supplied to heat carriers by the low energy photons and 21.7% by the high energy ones.

The object of the investigation is GaAs p-n junction illuminated by laser 1.06 μm-long laser light with maximum intensity of 10 MW/cm^2 and pulse duration of 25 ns. The photon energy of 1.16 eV is less than the band gap of GaAs, 1.42 eV. In this case the electron-hole pair generation occurs only through the two-photon absorption since GaAs is well-known for this relatively expressed process [2], and carrier heating happens both because of the intraband and interband light absorption. It is worth noting that the generation-caused photovoltage and the hot carrier photovoltage oppose each other due to their inverse polarities.

As for conclusion, to raise the efficiency of a single junction solar cell, the negative effect of hot carriers needs to be reduced.

References

[1] W. Shockley and H. J. Queisser, Detailed balance limit of efficiency of p–n junction solar cells, J. Appl. Phys. 32, 510-519, (1961).
[2] W. Hurlbut, Y. Lee, et al., Multiphoton absorption and nonlinear refraction of GaAs in the mid-infrared, Opt. Lett. 32, 668–670, (2007).

Synthesis and Characterization of Graphene Oxide and its Liquid-Crystalline Phase

Melikyan Yeghvard [1,*], Gharagulyan Hermine[1], Hayrapetyan Vardan[1], Kirakosyan Khachatur[1], Yeranosyan Mkrtich[1]

[1] *A.B. Nalbandyan Institute of Chemical Physics NAS RA*

[*] *E-mail:* yeghvard.meliqyan@gmail.com

Two-dimensional materials, namely the graphene family have been gaining increasing interest in optics, electronics, materials science, and biotechnology due to their unique optoelectronic, thermal, mechanical, and chemical properties [1]. However, the most applicable graphene-based structure that has a potential for mass-production with specified optical properties is graphene oxide (GO) and its liquid crystalline (LC) phase especially due to structural ordering, optical anisotropy, elastic, electro-optical, non-linear optical properties, as well as sensitivity to electromagnetic, light, pressure, and temperature field, which provide additional opportunities for the improvement of nanostructured thin films' characteristics and their external control [2].

In this work, we focus on the synthesis of graphene oxide and its liquid crystalline phase formation. The liquid phase exfoliation combined technique assisted by ultrasound and mechanical stirring was used to synthesize few-layer graphene oxide. It is based on the exfoliation of graphite intercalated compounds in an appropriate solvent. The LC phase of GO with improved optoelectronic properties is obtained by proper selection of the solvent, the average aspect ratio of GO sheets, and the correct control of the concentration of the GO flakes. Improvement of structural, electrochemical, and electro-optical features of GOLC phases was done by the addition of organic molecules (functional groups in liquid crystals, such as replacing OH with aliphatic D- or L-amino acid). The structure, number of layers, particle size, and morphology, as well as optoelectronic peculiarities of the synthesized material, were characterized by X-ray diffraction (XRD), atomic force microscopy (AFM), dynamic light scattering (DLS), infrared (IR), ultraviolet-visible (UV–vis), and Raman spectroscopy.

Besides its simplicity, low cost, and scalability, the proposed method provides a quite good uniform size distribution and a large quantity of produced GO which in turn enables observing new LC phases and their alignment controlling. We expect that our results will improve the performance of GOLC-based devices.

Acknowledgment

This work was supported by Grant 21SCG-2J022 of the Science Committee of the Ministry of Education, Science, Culture, and Sport of the Republic of Armenia.

References

[1] 1. R. Mas-Balleste, C. Gomez-Navarro, J. Gomez-Herrero, F. Zamora, "2D materials: To graphene and beyond", Nanoscale, 3, 20–30 (2011).

[2] 2. T. Yun, G.H. Jeong, S.P. Sasikala, and S.O. Kim, "2D graphene oxide liquid crystal for real-world applications: Energy, environment, and antimicrobial", APL Materials 8, 070903 (2020).

Optical properties of laser gain medium based on active matrix of Alq_3 derivatives

Paulsone Patricija [1,*], Zarins Elmars [1], Vembris Aivars[1]
[1] *Institute of Solid State Physics, University of Latvia*
[*] *E-mail:* paulsone@cfi.lu.lv

Popular laser dye 4-(dicyanomethylene)-2-methyl-6-(p-dimethylaminostyryl)-4H4H-pyran (DCM) has good light amplifying properties with emission in the red spectral region and has been used in organic solid-state lasers as the gain medium [1]. The main problem of DCM is crystallization which reduces optical properties of the light amplifying system.

This problem can be solved by using host – guest system with Förster resonance energy transfer (FRET) mechanism, where the host organic semiconductor tris(8-hydroxyquinoline) aluminum (Alq_3) is doped with the guest - organic dye molecules (DCM) [2].

In this work, two Alq_3 derivatives in combination with five DCM derivatives are investigated. The investigated compounds can form amorphous thin films from the solution by the spin-coating method. The following optical properties of the samples were measured: absorption and emission spectra, photoluminescence kinetics and quantum yield. For the best systems amplified spontaneous emission (ASE) measurements were made. Thin film absorption and emission measurements indicate that FRET between Alq_3 and DCM molecules is possible due to the overlap of the Alq_3 emission spectrum and the DCM absorption spectrum.

From obtained data, it can be concluded that for some of the systems the FRET could be with 100% efficiency. The measured ASE excitation threshold energies are compared with the previously obtained ASE threshold energies of DCM thin films. Results show that ASE threshold energies are much lower for host-guest systems than pure DCM thin films. Therefore, these systems could be applicable in solid-state lasers as the gain medium.

References

[1] P. R. Hammond. (1979). Laser dye DCM and its spectral properties, synthesis and comparison with other dyes in the red, Opt. Commun., 29(3), 331-333
[2] V. G. Kozlov, et.al. (1999). Current Opinion in Solid State and Materials Science Lasing action in organic semiconductor thin films, 203 - 208

Photochromic properties of BaMgSiO4:Fe

Ozols Haralds[1,*], Antuzevics Andris[1], Krieke Guna[1]
[1] *Institute of Solid State Physics, University of Latvia*
[*] *E-mail:* Haralds.Ozols@cfi.lu.lv

Organic compounds are mostly used as photochromic materials in industry due to their excellent contrast; however, they are not thermally resilient and have a limited number of cycles of color change. BaMgSiO4:Fe is a material with good contrast and high repeatability of color change and is also thermally resilient.

In this work BaMgSiO4:Fe samples with Fe concentrations ranging from 0,01 to 1 mol% as well as temperature and atmosphere during synthesis were varied. Optical and electron paramagnetic resonance (EPR) spectroscopy techniques were applied to characterize the samples.

After irradiation with UV light the absorbance of the samples at green spectral region greatly increases. The color can be bleached by 532 nm light. The photochromic effect can only be observed in the samples that were heated in reducing 5%H2 95%Ar atmosphere.

The origins of the photochromic effect and means of the effect‘s enhancement in BMSF are discussed based on the experimental results.

Acknowledgment
Financial support provided by Scientific Research Project for Students and Young Researchers “Origin and enhancement of photochromic effect in BaMgSiO4:Fe” realized at the Institute of Solid State Physics, University of Latvia is greatly acknowledged.

References
[1] Akiyama, M., Yamada, H., Sakai, K. (2011). Photochromism enhancement in reduced tridymite BaMgSiO4 by Fe-doping. In Journal of the Ceramic Society of Japan (Vol. 119, Issue 1389, pp. 338–341). Ceramic Society of Japan.
[2] Ren, Y., Yang, Z., Wang, Y., Li, M., Qiu, J., Song, Z., Yu, J., Ullah, A., Khan, I. (2020). Reversible multiplexing for optical information recording, erasing, and reading-out in photochromic BaMgSiO4:Bi3+ luminescence ceramics. In Science China Materials (Vol. 63, Issue 4, pp. 582–592). Springer Science and Business Media LLC.

Approbation of accommodation facility test for computerized vision screening protocol

Bertule Laura[1,*], Fomins Sergejs[1], Truksa Renars[1], Jansone-Langina Zane[1], Kalnica-Dorosenko Kristine[1], Panke Karola[1], Kassaliete Evita[1], Slabcova Jelena[1], Krumina Gunta[1],

[1] *University of Latvia, Faculty of Physics and mathematics, Department of Optometry and Vision Science, Jelgavas street 1, Riga, Latvia, LV-1004*

[*] *E-mail:* laurabertule@inbox.lv

Introduction. The method of assessing the accommodation facility is performed at a distance of 40 cm and assumes that the accommodation is alternately relaxed and tensioned by +2.00 D and –2.00 D lenses (Allen & O'Leary, 2006). Standard clinical tests require that the results be based on the patient's subjective interpretation of a clear image, including inaccuracies (Burns et al., 2014). To make the accommodation facility test more objective, the aim was to create a computerized test of accommodation facility and compare it with a standard clinical method.

Method. Subjects consisted of 74 participants between 19 and 43 years of age. On the computer screen were performed five optotypes and the participant's task is to detect in which direction is located a hole in the optotype. The test was started with a +2.00 D lens, as soon as a clear image is reported, replaced with a -2.00 D lens. Two types of lens replacement were used for the approbation of the computerized test - a manual hand lens flipper and an automated lens flipper machine. 62 participants had manual hand lens flipper accommodation facility test (1) with a clinic vision card (a) and test cards presented on a computer screen (b). An additional 11 participants were measured with an automated lens flipper machine (2).

Results. A moderately close correlation was observed between the standard method (1a) and the computerized hand lens flipper method (1b) ($r = 0.54$, $p < 0.01$), where the mean accommodation facility for 62 participants with the standard method was 10.6 cycles / min, but with the computerized method of hand lens flipper 6.8 cycles / min ($p < 0.05$). For the 11 participants who underwent automated lens flipper replacement, the average result was 4.4 cycles / min. In the automated lens flipper test (2) with a +2.00 D lens, the response time was 4.5 ± 1.5 seconds significantly longer than in the standard method ($p < 0.01$) and with a -2.00 D lens, the response time was 3,0 ± 1,5 seconds, which was not significantly different from the values obtained in the standard method (1a) and the computerized hand lens flipper method (1b).

Conclusions. The computerized accommodation facility method (1b) shows result of 3.8 cycles/min lower than the standard method (1a). The method of automated lens flipper replacement (2) shows average 8.1 cycles/min lower results comparing to standard method. The accommodation relaxation time with a +2.00 D lens is statistically different between the automated flipper method (2) and the standard method (1a), indicating that the result is affected by the test distance to the computer screen and participants tend to perform the test at a distance greater than 40 cm.

Keywords: accommodation facility, standard test, hand lens flipper, automated lens

flipper, computerized test.

Acknowledgment
The research is being developed by LIAA and LU project no. KC-PI-2020/10 “Development of vision screening and training equipment”.

References
[1] Gallaway, M., & Mitchell, L. (2010). Validity of the VERA visual skills screening. Optometry, 81, 571-579.
[2] Radhakrishnan, H., Allen, P., & Charman, W. (2007). Dynamics of accommodative facility in myopes. Investigative Ophthalmology & Visual Science, 48(9), 4375-4382.
[3] Scheiman, M., & Wick, B. (2008). Clinical management of binocular vision (3rd ed.). Wolters Kluwer.

~~Computerised visual acuity test and crowding effect~~

Bukša Ieva Ance[1], Kassaliete Evita[1,*], Slabcova Jeļena[1], Panke Karola[1], Kalniča-Dorošenko Kristīne[1], Jansone-Langina Zane[1], Trukša Renārs[1], Krūmiņa Gunta[1]

[1] *Latvijas Universitāte, Fizikas, matemātikas un optometrijas fakultāte, Optometrijas un redzes zinātnes nodaļa, Rīga, Latvija*

[*] *E-mail:* evita.kassaliete@lu.lv

Introduction. Vision is one of the most important senses, witch allows us to explore the world around us. Visual acuity measurement is the first thing optometrist measures in his office. Visual acuity is the ability to identify stimulus from a distance. Visual acuity measurement allows to estimate whether or not there is changes in visual system (Marsden et al., 2014). Crowding effect is a phenomenon where around reference optotype, there are other optotypes (van den Berg et al., 2007). Crowding effect plays an essential role in clinics, also it has an impact on visual acuity measurement. If the interval between optotypes increases or crowding effect impact reduces, the visual acuity has a higher value (Lalor et al., 2016, Hairol et al., 2016). The aim of this study is to compare the stimulus of the computerized visual acuity test with the standart stimulus, so it would be possible to estimate the treshold of visual acuity in patients.

Methods. 42 pacients participated in this study. Including criteria was the visual acuity, witch could not be worse than 0,2logMAR units. Participans mean age was 23 ± 5 years. Visual acuity was measured with three different visual acuity charts, with one eye at the time, using (1) Freiburg Vision Test (FrACT) Landolt C, Snellen E and Sloan optotypes (2) Early Treatment of Diabetic Retinopathy (ETDRS) chart, and (3) computerized visual acuity test with specific optotypes. It was possible to change the influence of crowding effect in computerized visual acuity test.

Results. Using FrACT test, mean visual acuity with Landolt C optotypes was 0,04 ± 0,16 logMAR units, with Snellen E optotypes it was 0,03 ± 0,13 logMAR units, but the lowest mean visual acuity was with Sloan optotypes 0,07 ± 0,14 logMAR units. With ETDRS chart mean visual acuity was 0,01 ± 0,14 logMAR. Computerized visual acuity test showed the highest mean visual acuity (–0,06 ± 0,13 logMAR units) when space between optotypes was 0,5. When it was reduced to 0,25 mean visual acuity was –0,02 ± 0,12 logMAR units. Computerised test visual acuity measurements did not show signifficant differences in visual acuity if comparing results to golden standart or ETDRS chart, in both cases, when distance between optotypes was either 0,25 or 0,5.

Conclusions. Computerised test shows higher average visual acuity than FrACT or ETDRS chart. The most similar visual acuity results to ETDRS chart was obtained when distance between optotypes in computerised test was 0,25 because the design of those two tests are very similar, they both include crowding effect.

Keywords. Visual acuity, crowding effect, Snellen E optotypes, Landolt C optotypes, Sloan optotypes.

Acknowledgement

Research was developed within LIAA and LU project No. KC-PI-2020/10 “Development of vision screening and vision training equipment”.

Add-On Anterior Segment SD-OCT Applications in Modern Scleral Lens Practice

Petrovica Inese[1], Svede Aiga[1,*], Ikaunieks Gatis[1]
[1] *University of Latvia, Faculty of Physics, Mathematics and Optometry, Department of Optometry and Vision Science*
[*] *E-mail:* inese.petrovica@lu.lv

Scleral contact lenses are first choice therapeutic solution in corneal ectatic disorders like keratoconus, post-surgical or post-disorder corneal irregularities, and in severe ocular surface disease when medications are not effective [1]. Although scleral contact lens performance is outstanding and provides best quality of vision, there are several challenges for practitioners. The mostly contact lens specialists avoid fitting this lens modality cause current diagnostic methods are not designed to scleral lens fitting as it is in the rigid corneal lens fitting for example, special trial sets are necessary and several re-ordering of trial lenses can be needed. Therefore, scleral lens fitting is time consuming and financial burden is high. When evaluating scleral contact lens fit the following characteristics are estimated - 1) central clearance (optimal 200 μm to 300 μm), 2) limbal clearance (100 μm, minimum is 50 μm), and 3) lens edge fit (best fit - parallel to sclera, steep edge profile - big tangent angle, flat edge profile - small tangent angle of the lens edge) [2]. Unlike slit lamp imaging, add-on AS-OCT allows to take objective measures of the scleral lens fitting parameters. The disadvantage of the OCT is that there are only manual measuring tools in the current commercial units. There are no software tools for contact lens fitting as it is for diagnostic purposes - corneal pachymetry maps and epithelial thickness maps.

The study showed, that providing manually measurements of the central clearance, the less dispersion was when reverse color OCT scans used (coefficient of variation (CoV) for greyscale scans was 3.47% and for reverse color scans 2.50%). The CoV of manual edge profile measurements was 12.64%. Since less dispersion of measurements when obtaining automatic central corneal (CoV 0.5%) and epithelial (CoV 3.9%) thickness with OCT, there would be necessary to develop program tools for automatic estimation of central clearance, limbal clearance and lens edge profile fit to increase accuracy, improve overall estimation of lens fit, facilitate recalculations of the lens technical parameters, and optimize scleral contact lens fitting time and therefore to decrease expenses [3].

References

[1] Robertson, D., & Cavanagh, H. D. (2011). Contact Lens Applications in Corneal Disease. In Cornea (Fifth Edition). Elsevier Inc.
[2] Barnett, M., Courey, C., Fadel, D., Lee, K., Michaud, L., Montani, G., van der Worp, E., Vincent, S. J., Walker, M., Bilkhu, P., & Morgan, P. B. (2021). CLEAR - Scleral lenses. Contact Lens and Anterior Eye, 44(2), 270-288.
[3] Berzina, A., (2021). The repeatability of corneal and epithelial thickness measurements with optical coherence tomography. Bachelor's thesis, University of Latvia

EEG assessment of disparity-driven brain activity

Abdullayeva Albina[1], Naderi Mehrdad[1], Pladere Tatjana[1], Krumina Gunta[1]
[1] *Department of Optometry and Vision Science, Faculty of Physics, Mathematics and Optometry, University of Latvia*
[*] *E-mail:* abdullayevaalbina97@gmail.com

Depth perception is the ability to perceive three-dimensional (3D) images and judge the distance of objects. The main sources for depth perception are depth cues which are combined to extract the information about the third dimension [1]. Binocular disparity is one of the most important depth cues required for accurate depth judgements.

Most of the research aiming at elucidating the neural correlates of processing binocular disparity was performed using 3D anaglyph images and two-dimensional (2D) images [2-4]. These studies revealed that the specific cortical areas, such as parietal and occipital regions, are mainly responsible for processing disparity. It has been also shown that the information about binocular disparity is available early in visual processing. However, the effect of crossed and uncrossed disparities received little attention in comparison to the investigation of the presence of image depth [2, 5]. Thus, it remains unclear what differences in the global electroencephalogram (EEG) features should be expected depending on the type of disparity.

To investigate the disparity-driven brain activity, subjects judged the depth of anaglyph images. Each trial started with a fixation cross that was displayed in the middle of the flat-panel monitor for 1 second. Next, four circles were displayed. One of them had different binocular disparity in comparison to three others. The task was to discern whether this circle appeared closer to or further away from the viewer. The response was submitted using the keyboard. The oddball paradigm was used in the experimental design aiming at amplifying the strength of the cortical responses. The electrical activity of the brain was captured with the EEG system.

Acknowledgment
The authors acknowledge the support from the Latvian Council of Science project No. lzp-2021/1-0399 (Development of guidelines for evaluating the visual effectiveness and ergonomics of innovative 3D displays).

References
[1] Howard, I. P., Rogers, B. I. (2012). Perceiving in Depth: Stereoscopic Vision, Vol. 2. Oxford University Press: York.
[2] Kasai, T., Morotomi, T. (2001). Event-related brain potentials during selective attention to depth and form in global stereopsis. Vision Research, 41, 1379-1388.
[3] Oliver, Z. J., Cristino, F., Roberts, M. V., Pegna, A. J., Leek, E. C. (2018). Stereo viewing modulates three-dimensional shape processing during object recognition: A high-density ERP study. Journal of Experimental Psychology: Human Perception and Performance, 44(4), 518-534.
[4] Pegna, J. A., Darque, A., Roberts, M. V., Leek, E. C. (2018). Effects of stereoscopic disparity on early ERP components during classification of three-dimensional objects. Quarterly Journal of Experimental Psychology, 71(6), 1419-1430.
[5] Li, Y., Zhang, C., Hou, C., Yao, L., Zhang, J., Long, Z. (2017). Stereoscopic processing of crossed and uncrossed disparities in the human visual cortex. BMC Neuroscience, 18, 80.

Custom device for disinfection of public transportation surfaces with UV-C LED illumination

Vabulnieks Klavs[1,*], Mezule Linda[2], Patlins Antons[1]
[1] *Institute of Industrial Electronics and Electrical Engineering, Riga Technical University*
[2] *Water Research and Environmental Biotechnology Laboratory, Riga Technical University*
[*] *E-mail:* klavs.vabulnieks@gmail.com

In this work a device prototype design using UV-C LEDs for disinfection of public transportation door-opening buttons has been described.

Due to the airborne infectious diseases that can set on surfaces and can be contracted in common used spaces, there is a need for an effective, inexpensive, fast and reliable way to disinfect surfaces.

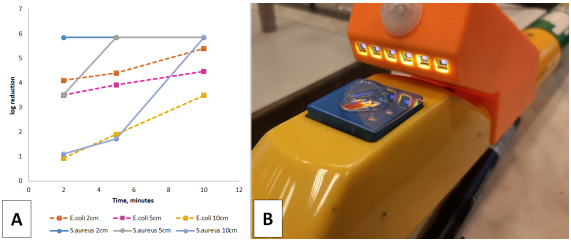


Figure 1: A: Graph shows log reduction of E. coli and S. aureus bacteria dependence of distance and exposure time of UV-C LED. B: Picture of developed prototype being tested with bacteria on the surface of the button.

The results show that with just 13.3mW radiation of UV-C LEDs at 5cm distance and 5 minute exposure time is sufficiently effective, reaching 4 log10 reduction of viable bacteria. Results also show that different bacteria are not affected equally by UV-C light. E. coli is being reduced less gradually than S. aureus. The exposure time with E.coli looks more important where S. aureus is affected more by distance of radiation source. After testing LED effectiveness, prototype was made to disinfect one of most touched contact surfaces. It also has been tested with bacteria, but shows lesser results, compared to tests, because of considerable position angle of LEDs to the surface.

Thanks to the novel and simple design of this device the disinfection of any high-risk contact surface could be done safely, even if people are present at the public transportation and other public areas, continuously and environmentally friendly.

Acknowledgment
I'd like to acknowledge Dr. Phys. Atis Skudra for helping with light source wavelength measurement validation at High Resolution Spectroscopy and Light Source Technology Laboratory, University of Latvia.
This research has been supported by Project 1.1.1.2/VIAA/4/20/658 "Adapting the public transport system to the COVID-19 challenge, ensuring its sustainability".

Laser speckle imaging system for antibacterial resistance assessment

Plorina Emilija V.[1,*], Balmages Ilya[1], Reinis Aigars[2], Kistkins Svjatoslavs[1], Lihachev Alexey[1], Bliznuks Dmitrijs[3], Lihacova Ilze[1]

[1] *University of Latvia, Institute of Atomic Physics and Spectroscopy, Riga, Latvia*

[2] *Pauls Stradins Clinical University Hospital, Riga, Latvia*

[3] *Riga Technical university, Riga, Latvia*

[*] *E-mail:* evplorina@gmail.com

Due to widespread use of antibiotics during the last century many common bacterial species have acquired resistance factors and become insensitive to traditional antibiotics. For appropriate treatment in case of infection it is necessary to quickly determine susceptibility to antibiotics of a specific isolated pathogen. Recently, it has also been a significant factor in treatment of COVID-19 patients as severity of disease is strongly related to presence of bacterial coinfection. Finding the effective antibiotic treatment quickly is crucial to reduce mortality of patients and to avoid the formation of new antibiotic-resistant bacteria due to preventative antibiotic use.

Laser speckle imaging has been demonstrated as an improved method for measuring bacterial growth[1] compared to traditionally used laboratory methods. Laser diodes create a specific reflection pattern depending on the surface the laser light illuminates. If the pattern is tracked with a camera over time it is possible to detect sub-micron motions due to variation of speckle intensity which is a suitable scale for study of bacteria. The system will be compatible with the use of Petri dishes where bacterial activity will be tracked to find zones where antibiotics have been successful in sterilizing the dish. Additionally, AI recognition techniques will be trained on the data to advance detection of changes in the complex laser speckle pattern. The system will be tested in Pauls Stradins Clinical University Hospital laboratory.

Acknowledgment

This work has been supported by European Regional Development Fund project "Rapid assessment system of antibacterial resistance for patients with secondary bacterial infections" (No. 1.1.1.1/21/A/034).

References

[1] Ilya Balmages, Janis Liepins, Stivens Zolins, Dmitrijs Bliznuks, Ilze Lihacova, and Alexey Lihachev, "Laser speckle imaging for early detection of microbial colony forming units," Biomed. Opt. Express 12, 1609-1620 (2021)

Photoplethysmographic assessment of topical heating induced vasomotor response in the foot

Lauska Paula[1,*], Marcinkevics Zbignevs[1], Rubins Uldis[2], Grabovskis Andris[2]
[1] *Department of Human and Animal Physiology, University of Latvia, Jelgavas str.1, Riga, Latvia, LV-1586*
[2] *Institute of Atomic Physics and Spectroscopy, University of Latvia, Jelgavas str 3, Riga, Latvia, LV-1586*
[*] *E-mail:* paulalauska44@gmail.com

Introduction. Topical skin heating is a well-known provocation test for induction of cutaneous vasomotor response, potentially characterizing endothelial function and sensory nerve fiber state, which can be utilized for early diagnostics of diabetes and neuropathy. Traditionally such testing is performed by laser Doppler; hence technique is sophisticated and not widely available to general practitioners; therefore a more affordable alternative is required. Imaging photoplethysmography is a simple and non-intrusive technique for blood pulsation detection and can be used in assessment of vasomotor response[1]. The aim of the present pilot study was to explore the capability of multispectral imaging photoplethysmography for assessment of foot cutaneous sensory nerve ending function by means of topical skin heating [2] as this site is prone for early pathophysiological changes.

Methods. The study comprised healthy young volunteer (23 y.). Two thermostatic heating probes were situated on the subject's dorsal aspect of the foot and heated using the following protocol: 10 min preheating at 32 C^{o} with the following heating (20 min at 43 C°, for the first probe and 45 C° for 18 min for the second probe). During the entire procedure skin region was illuminated by a multispectral light source comprising 420nm, 567nm, 800nm wavelength, and video simultaneously recorded with three monochromatic cameras equipped with narrowband optical filters (420 nm, 540 nm, 800 nm; bandwidth 10nm). The vasomotor response characterizing parameters and flare were assessed at three wavelengths in recordings from different days.

Results. The most reliable data was obtained at 540 nm and 420 nm wavelengths, displaying a typical perfusion trend, with initial peak (P1), nadir (ND), and plato phase (PL). The smallest intra-subject variation was observed at G (P1:1.0%, ND:2.6%, PL:12.5%) in comparison to B (P1:15.7%, ND: 21.1%, PL:29.2%), with no differences for flare area and flare index. Preliminary results indicate the reliability of imaging photoplethysmography for the assessment of cutaneous vasomotor response in the foot at 540nm illumination, however further studies are required.

Acknowledgement
This study was financially supported by research Project "Imaging Photoplethysmography for Chronic Pain Assessment" No. LZP-2018/1-0188.

References
[1] Z.Marcinkevics, U.Rubins, J.Zaharans, A.Miscuks, E.Urtane, and L.Ozolina-Moll ," J.Biomed. Opt., 21, p. 35005, (2016).
[2] U.Rubins, Z.Marcinkevics, I.Logina, A.Grabovskis, and E.Kviesis-Kipge, Spie. Proc., 10885, p. 8.(2019).

Study of gain characteristics of an Er/Yb-doped double-clad fiber amplifier

Lukosevics Ingars[1,*], Supe Andis[2], Spolitis Sandis[2], Zakis Kaspars[2], Olonkins Sergejs[3], Udalcovs Aleksejs[2], Senkans Ugis[2], Elsts Edgars[1], Grube Jurgis[1], Bobrovs Vjaceslavs[2]
[1] *Institute of Solid State Physics, University of Latvia*
[2] *Institute of Telecommunications, Riga Technical University*
[3] *AFFOC Solutions*
[*] *E-mail:* ingars@cfi.lu.lv

Recently, cladding-pumped doped fiber amplifiers have attracted interest as they could be applied in space-division multiplexed (SDM) systems, which provide a transmission capacity increase in a cost-effective way [1].

The wavelength dependence of Er^{3+}/Yb^{3+} co-doped fiber amplifiers (EYDFA) absolute gain and gain uniformity for fiber lengths in the range of 2–7 m has been theoretically and experimentally analyzed.

The simulation model has been created in the software VPIphotonics Design Suite. The main purpose of simulations is to determine possible gain characteristics and provide baseline values of fiber length and pump parameters for the experimental setup. In detail, the simulation model of the cladding-pumped EYDFA is described in [2].

In the experimental setup to obtain the per-channel gain of the experimental EYDFA, we use the input signal formed by filtering a wideband amplified spontaneous emission (ASE) noise (covering C and L bands with a 10 dB bandwidth of 1526–1630 nm). The pump diode spectrum is centered around 975 nm.

The experimental and simulation results of the overall level of amplification and the envelope of the gain spectrum show the best agreement when the EYDF is 3 and 5 meters long.

Acknowledgment
Funding: This work has been supported by the European Regional Development Fund project No.1.1.1.1/18/A/068. The Institute of Solid State Physics, University of Latvia as a Center of Excellence has received funding from the European Union's Horizon 2020 Framework Programme H2020-WIDESPREAD-01-2016-2017-TeamingPhase2 under grant agreement No. 739508, project CAMART2.

References
[1] N. Yoshikane and T. Tsuritani, "Recent Progress in Space-Division Multiplexing Optical Network Technology", 2020 International Conference on Optical Network Design and Modeling (ONDM), Castelldefels, Barcelona, Spain, 2020, pp. 1-4
[2] A. Supe et al., "Cladding-Pumped Erbium/Ytterbium Co-Doped Fiber Amplifier for C-Band Operation in Optical Networks". Applied Sciences, 2021, 11(4), 1702

Part III
Poster Session 1

Fast Thermoelectric Detectors for UV Radiation

Kuzanyan Astghik [2], Nikoghosyan Vahan [1], Kuzanyan Armen[1], Kharatyan Gor[3,*], Harutyunyan Sergey[1]

[1] *Institute for Physical Research, National Academy of Sciences of Armenia, Ashtarak,Armenia*

[2] *University of California, Los Angeles, CA, USA*

[3] *Russian-Armenian University, Yerevan, Armenia*

[*] *E-mail:* gor.kharatyan@rau.am

UV radiation detectors are used in many areas of modern science and technology,particularly in quantum information processing, lidar studies of the upper atmosphere, fluorescence UV microscopy and UV astronomy. Therefore, the creation of an inexpensive detector with high performance, simple design, and undemanding operating conditions is an urgent task. One solution to this task could be a thermoelectric single photon detector (TSPD)[1, 2].

We present results of modeling of heat propagation processes in the $SiO_2/W/FeSb_2/W/Al_2O_3$ five-layer detection pixel of TSPDtaking place after 3.1 - 7.1 eV single photons absorption. The computer simulationwas carried out based on theheat propagation equation from the limited volume using the three-dimensional matrix method for differential equations. The detector's operating temperature is 9 K. Temporal dependences of the signal intensity of detection pixelswith a surface of $10\mu m \times 10$ μm and 2 μm $\times$ 2 μm and layers different thicknesses are determined.

It is shown that by changing the thickness of the FeSb2 sensor from 0.05 μm to 1 μm, for 4.1 eV photons absorption the following parameters can be achieved: temperature change at the absorber–sensor interface of 22.36 - 21.56 mK, the maximal voltage on the sensor of 49.4 - 90.5 μV, and a count rate of 7.07 – 9.67 THz. Johnson and phonon noises are also calculated. It has been found that the signal-to-noise ratio of this detection pixel can be higher than 10. We can expect that the TSPD with SiO2/W/FeSb2/W/Al2O3detection pixels will have a high energy resolution, counting rate, and detection efficiency in the UV region of the electromagnetic spectrum.

References

[1] A.A. Kuzanyan, V.R. Nikoghosyan, A.S. Kuzanyan. IEEE Sens., J., 20 (6), 3040 (2019).

[2] A.A. Kuzanyan, V.R. Nikoghosyan, A.S. Kuzanyan. IEEE Sens., J., 20 (21), 12776 (2020).

2D Calculation of the Double Degenerated Bending Vibrations of the Linear Triatomic Molecules. The Case of the CaOH Molecule

Lizurchyk Artsiom[1,*], Khrapunova Aryna[1], Pitsevich George[1], Malevich Alex[1]
[1] *Belarusian State University, Minsk, Belarus*
[*] *E-mail:* arishka102000@gmail.com

Linear triatomic molecules represent a fairly large class of compounds of interest in many applications. It is well known that, in contrast to nonlinear triatomic molecules, linear ones have not three but four vibrational degrees of freedom. In this case, the bending vibration of such molecules turns out to be doubly degenerate. It is assumed that two deformation vibrations correspond to two bending coordinates describing the deformation of the molecule in two mutually perpendicular planes. It is also well known that the degeneracy of some excited bending states of linear molecules is canceled, which sometimes leads to a significant splitting of some energy levels and absorption bands in the IR spectra. We note that there are many works in the literature that present the theoretical values of the splitting of the corresponding energy levels. However, to the best of our knowledge, the authors do not provide detailed representation of the methodology for calculating such a splitting.

In practice, the formulation and solution of the one-dimensional vibrational Schrödinger equation for one of the bending coordinates is not difficult, but, as expected, both the ground and all excited bending states of molecules turn out to be non-degenerate and, as a result, cannot be split. It is not possible to imagine the distortion of the geometry of a linear triatomic molecule with a simultaneous (not necessarily identical) change in two orthogonal bending coordinates (θ_1 and θ_2). However, a purely mathematical approach made it possible to obtain a fairly simple relation that determines, at given values of θ_1 and θ_2, the resulting deformation of the molecule, which is described by the bending coordinate θ_3:

$$sin^2\theta_3 = sin^2\theta_1 + sin^2\theta_2$$

Using the obtained relation, the 2D potential energy surface (PES) of the CaOH molecule was calculated in coordinates θ_1 and θ_2 ($U(\theta_1, \theta_2)$). The calculation was performed at the MP2/cc-pVQZ and CCSD(T)/cc-pVTZ levels of theory both with and without energy optimization respect to Ca-O and O-H valence coordinates. The values of the two bending coordinates θ_1 and θ_2 varied in the range of of 135° - 225° with a step of 5°. In this case, the obvious symmetry properties were considered:

$$U(\theta_1, \theta_2) = U(\theta_2, \theta_1); U(\theta_1, \theta_2) = U(2\pi - \theta_1, \theta_2);$$
$$U(\theta_1, \theta_2) = U(\theta_1, 2\pi - \theta_2); U(\theta_1, \theta_2) = U(2\pi - \theta_1, 2\pi - \theta_2);$$

The calculated 2D PES were subsequently used to determine the potential energy in the 2D vibrational Schrodinger equation, which was then solved numerically using the DVR method [1-3]. The calculation results will be presented in the conference proceedings.

References

[1] D.O. Harris, G.G. Engerholm, W.D. Gwinn, J.Chem. Phys., 43 (1965) 1515
[2] R. Meyer, J.Chem.Phys., 52 (1970) 2053
[3] G.A. Pitsevich, A.E. Malevich, J.Appl. Spectr., 82 (2016) 893

Study of the Cosmological Model Based on Jordan-Bruns-Dicke Theory

Teryan Hripsime[1,*], Harutyunyan Gohar[1]
[1] *Yerevan State University, 1 Alex Manoogian, 0025, Yerevan, Armenia*
[*] *E-mail:* hripsime.teryan95@gmail.com

In the frame of this work, a cosmological model was investigated and accelerated expansion of the Universe at the early stage of evolution was shown. We studied the inflationary regime taking into account the conformal transformations of Jordan-Bruns-Dicke (JBD) modified theory. The cosmological model is considered in the presence of a conformally coupled field in the evolution of the Early Universe. Such a field, satisfying the condition of general covariance, leads to the appearance of an additional term in the functional of the action, which connects the scalar field with scalar curvature, which can apparently serve as an analogue of the potential energy of a scalar field. Such a variant of action arises in the Jordan-Bruns-Dicke theory as a result of the well-known conformal transformations of Bekenstein. The problem can be represented as an autonomous dynamical system, and qualitative methods can be used to analyze such a system. The evolution of the Universe at an early stage of development is considered in the framework of a conformal analogue of the modified Jordan theory in the case of taking into account the interaction of the scalar field with the gravitational field and the presence of the cosmological constant is considered. As a result, it was shown that the accelerated expansion of the Universe also takes place at the early stage of evolution. The presence of a scalar field along with the vacuum energy also leads to expansion with an exponential law, as in the case of the presence of vacuum energy, the density of which remains unchanged during the expansion of the Universe. With the inflationary expansion, in addition to what has been said, a mechanism is also needed to stop inflation, as a result of which the Universe heats up, passing into a hot stage. Cosmology analogues in optical systems will be studied, namely using techniques from nonlinear optics modified theories will be considered in the mentioned above field.

References

[1] R.M. Avagyan, E.V. Chubaryan, G.H. Harutunyan, A.A. Saharyan, Gen. Relative Gravity. 48, 21, 1-21, 2016

Structural and Spectral Property of the Intramolecular H-Bond in $C_6H_4(OH)_2$ Molecule

Kovaleva Liza[1,*], Kisuryna Darya[2], Khrapunova Aryna[1], Pitsevich George[1]
[1] *Belarusian State University, Minsk, Belarus*
[2] *University of Maryland, College Park, MD, USA*
[*] *E-mail:* arynakhrapunova@gmail.com

Catechol molecule ($C_6H_4(OH)_2$) is representative of a separate class of aromatic hydrocarbons. It is an important component of biochemical, industrial and commercial products. In particular, dihydroxybenzenes are used in gas filled polymers (foam plastics) which, owing to their unique combination of low density and high strength with very good soundproofing and thermal insulation, have been widely used in various areas of human activity. In a recently published article [1] a rotationally resolved Fourier Transform far-infrared spectrum of the free and bonded O-H groups forming the intramolecular hydrogen bond was recorded. Studying the formation of H-bonds and their influence on the energy, structural and spectroscopic characteristics of molecules and complexes still attracts the attention of researchers. In such studies, vibrational spectroscopy techniques have been successfully used. Despite a great progress in a hydrogen bond studying, one cannot state as yet that today there is a possibility to predict the whole collection of sometimes controversial changes in structure-spectral characteristics caused by its formation. The intramolecular H-bond represents the most challenge case.

To study structural and spectral property of the intramolecular H-bond in the catechol molecule anharmonic calculations of the fundamental vibrations have been carried out using a standard model of anharmonicity accounting in the context of the second order perturbation theory using the quantum-chemical program set Gaussian 09. The analysis of the hydroxyl group vibrations was also carried out by 1D-3D PESs building using Cartesian coordinates of donor hydrogen atom H_6. For the convenience the origin of a Cartesian coordinate system was placed at H_6. X axis was directed along O_1-H_6 bond from the oxygen atom to the hydrogen atom. Y axis was directed towards atoms C_3 and C_4 in the plane of the molecule. Z axis complemented axes X and Y to a right-hand triple. The potential energy values were calculated in the nodes of a three-dimensional grid stepping by 0.1Åfor the intervals of H_6 shifting from the equilibrium position from -0.4Åto +1.2Åalong X axis, from -0.9Åto +0.9Åalong Y axis and from -0.9Åto +0.0Åalong Z axis. So, the energy was calculated in more than 3200 points. Taking into account the plane structure of $C_6H_4(OH)_2$ molecule we must have $U(X,Y,Z) = U(X,Y,-Z)$. Owing to this condition the number of points, for which the energy was determined accurately, exceeds 6000. Frequency values and wave functions were determined by numerical solution of the equation:

$-\mathrm{R}\frac{d^2\psi(x)}{dx^2}+\mathrm{U(x)}\psi(x)=\mathrm{E}\psi(x);$

$-\mathrm{R}\frac{d^2\psi(x,y)}{dx^2}-\mathrm{R}\frac{d^2\psi(x,y)}{dy^2}+\mathrm{U(x,y)}\psi(x,y)=\mathrm{E}\psi(x,y);$

$-\mathrm{R}(\frac{d^2\psi(x,y,z)}{dx^2}+\frac{d^2\psi(x,y,z)}{dy^2}+\frac{d^2\psi(x,y,z)}{dz^2})+\mathrm{U(x,y,z)}\psi(x,y,z)=\mathrm{E}\psi(x,y,z);$

where $\mathrm{R}=\frac{\hbar^2}{2}\mu_{AB}^{-1}l_0^{-2}$; $\mathrm{x}=\frac{X}{l_0}$; $\mathrm{y}=\frac{Y}{l_0}$; $\mathrm{z}=\frac{Z}{l_0}$; μ_{AB} - the reduced mass of A and B atoms. Here A denotes O, and B-H. Above equations were solved using Mathematica program set.

The way of the solution is described in detail in [2,3]. Using this approach the values of the frequencies of the H-bonded hydroxyl group vibrations were found. Equilibrium geometrical parameters as well as values of the force constants definitely indicate that in the $C_6H_4(OH)_2$ molecule occurs weak H-bond.

References

[1] J. Bruckhuisen and etc, Molecules 26 (2021) 3645
[2] G.A. Pitsevich, A.E. Malevich, OPJ, v.2, (2012), p.332
[3] G. Pitsevich, A. Malevich, I. Doroshenko, E. Kozlovskaya, V. Pogorelov, V. Sablinskas, V. Balevicius Spectrochim. Acta A 120 (2014) 585

On-chip SU-8 whispering gallery mode humidity sensor

Milgrave Lase[1,*], Alnis Janis[1], Bundulis Arturs[2], Atvars Aigars[3]
[1] *University of Latvia, Institute of Atomic Physics and Spectroscopy, Riga, Latvia*
[2] *University of Latvia, Institute of Solid State Physics, Riga, Latvia*
[3] *University of Latvia, Institute of Astronomy, Riga, Latvia*
[*] *E-mail:* lase.milgrave@lu.lv

Humidity sensing and control is necessary in many areas (industrial, research, medical) [1]. However, sensors still need to improve in reliability, especially in low or high relative humidity (RH). One option is to use whispering gallery mode resonators (WGMR). They can be used as optical sensors by choosing a material for the resonator that senses changes in the surrounding environment. Light is trapped in the resonator due to total internal reflection and photons make many roundtrips in the cavity, leading to high Q factor and sensitivity [2]. We created an on-chip WGM ring resonators that are connected to waveguides on the same chip. We used glass substrate on which SU-8 waveguides and resonators are formed using lithography methods. SU-8 is a negative photoresist that in the presence of gasses changes its refractive index [3]. This change is seen as resonance shift in the transmitted signal. By following the shift of one or more peaks, one can determine the shift in relative humidity. SU-8 is not selective, for this reason various coatings can be used to improve it. One example is PMMA (polymethyl methacrylate). By controlling the pore size of PMMA, it is possible to create selective coatings that absorb specific molecules based on their size.

Acknowledgment
This research was funded by ERDF project No. 1.1.1.5/19/A/003 "The Development of Quantum Optics and Photonics in University of Latvia".

References

[1] R. Narayanaswamy and O. S. Wolfbeis, Optical Sensors: Industrial, Environmental and Diagnostic Applications, vol. 4. Springer, 2006.
[2] M. R. Foreman, J. D. Swaim, and F. Vollmer, "Whispering gallery mode sensors," Adv. Opt. Photonics, vol. 7, pp. 168–240, 2015.
[3] C. Lemieux-Leduc, R. Guertin, M.-A. Bianki, and Y.-A. Peter, "All-polymer whispering gallery mode resonators for gas sensing," Opt. Express, vol. 29, no. 6, p. 8685, 2021.

Predicting Optical Properties of Porous Anodized Aluminum Oxide Covered with Gold Nanoparticles by Finite-Difference Time-Domain Modelling

Jurkevičiūtė Aušrinė[1,*], Prikulis Juris[1]
[1] *Institute of Chemical Physics, University of Latvia, Jelgavas iela 1, LV-1004, Riga, Latvia*
[*] *E-mail:* ausrine.jurkeviciute@lu.lv

The interaction between the electromagnetic waves and materials is of interest for many applications, especially in plasmonics for plasmon coupling [1], light scattering [2] and absorption [3], dipole interactions [4], etc. To better understand physical phenomena, theoretical model is required. The most precise but also the most limited method is analytical Mie theory: it gives the accurate result but is limited to spherical scatterers in a uniform environment [5]. More complex geometries require discretization methods such as finite-difference time-domain (FDTD) modelling [6].

Our goal is to create an optical sensor based on porous anodized aluminum oxide (PAAO) and metal nanoparticles (NP). In FDTD modelling, we can easily change PAAO thickness, NP size, light polarization and incidence angle to obtain the highest response. In this work, we present some examples of FDTD applications and results: from simple cases of single NP and dipoles in free space to more complex geometries. We obtain the same optical properties (absorption, scattering, and extinction cross sections and corresponding efficiencies, reflectance and transmittance) while varying a single parameter (diameter of the NP, gap between dipole particles, PAAO layer thickness, etc.) to determine how it affects the result.

The increase of the radius of gold NP in free space results in a red shift and widening of the peaks in scattering and extinction cross-section spectra. If the particle is placed in water, from around 75 nm NP radius second peak starts to appear in extinction cross section spectrum. For nanoparticle dipoles, the direction of polarization plays an important role on the results: electric field enhancement in the gap between the particles is obtained when the polarization is parallel to the axis of dipole. Thus, if the nanoparticles are laid in a periodic array and illuminated by linearly polarized light, the enhancement between the nanoparticles will be achieved only in one direction.

Acknowledgment
This research is supported by European Regional Development Fund postdoctoral project "Patterned hybrid multilayer films for optical sensors" (No. 1.1.1.2/VIAA/4/20/615).

References
[1] A. S. M. Mohsin, et al. *IEEE Photonics Journal* **10** (2018), p.4800610.
[2] W. Challener. *Optics Express* **11** (2003), p.3160.
[3] A. Centeno, et al. *2011 IEEE Applied Electromagnetics Conference (AEMC)* **3** (2011), p.5-8.
[4] W. Zhou, et al. *Nature Nanotechnology* **6** (2011), p.423-427.
[5] I. Kriegel, et al. *Beilstein Journal of Nanotechnology* **6** (2015), p.193-200.
[6] G. F. Mongelli. *International Journal of Chemistry, Mathematics and Physics* **3** (2019), p.15-17.

Influence of synthesis parameters on ultraviolet persistent luminescence of $Ca_2Al_2SiO_7:Pr^{3+}$

Nilova Dace[1,*], Antuzevics Andris[1], Krieke Guna [1]
[1] *Institute of Solid State Physics, University of Latvia*
[*] *E-mail:* nilovadace@gmail.com

Persistent phosphors are promising materials with many applications. In recent years, ultraviolet (UV) persistent luminescence has been investigated intensively, which has potential applications in medicine, disinfection, photocatalysis, etc. Lanthanide-doped complex oxides represent one of the material groups for which UV persistent luminescence has been observed. For example, $Ca_2Al_2SiO_7$ activated with praseodymium (Pr^{3+}) ions exhibits persistent luminescence in the UV-C range (200-280 nm)[1]. The mechanisms of persistent luminescence are related to the defects formed in the material; therefore, one of the methods to influence the properties of long-lasting luminescent materials is to control the formation of intrinsic defects by changing the conditions of the synthesis process or changing the concentration of activator ions in the material.

In this study, by changing the temperature and atmosphere during the syntheses, $Ca_2Al_2SiO_7$ samples activated with different concentrations of Pr^{3+} were prepared. The samples were characterized by X-ray diffraction (XRD), electron paramagnetic resonance (EPR), and luminescence spectroscopy methods. By analysing the luminescence parameters - intensity and duration - the synthesis conditions and activator concentration were evaluated and adjusted to optimize the UV-C persistent luminescence.

Acknowledgment
Latvian Council of Science, project "Defect engineering of novel UV-C persistent phosphor materials", project No. LZP-2021/1-0118 is gratefully acknowledged.

References
[1] Wang, X., Chen, Y., Liu, F. and Pan, Z. Solar-blind ultraviolet-C persistent luminescence phosphors. Nat. Commun. 11, (2020).

Tuning the localized surface plasmon resonance in ZnO nanoparticles

Tsokolakyan Astghik[1,*], Parsamyan Henrik[1], Asatryan Arevik[1], Hayrapetyan Vardan[1], Yeranosyan Mkrtich[1]

[1] *Institute of Chemical Physics of NAS RA*

[*] *E-mail:* astsokola@gmail.com

With the development of biotechnology and medical diagnostics the search for new materials has become a research focus area. The label-free, precise and cost-effective measurement of biomolecular interactions is an especially attractive goal for many researchers and manufacturers. In this aspect, plasmonic materials have gained increasing popularity in the sensing technologies, as they open new possibilities for accurate measurements based on highly controlled optical phenomena. The main sensing mechanisms based on plasmonic effects employ Surface Plasmon Resonance (SPR) and Localized Surface Plasmon Resonance (LSPR)[1]. The plasmonic resonances of conventional materials, such as Au and Ag lay in the visible and near infrared spectra. However, using metal-oxides will enable tuning the plasmonic resonance towards longer-wavelength infrared thus providing higher sensitivity and also less risks of damage to the biomaterials.

In our research, Ga- and Al-doped ZnO nanoparticles were prepared by Sol–gel method[2]. The LSPR induced light absorption and scattering on the metal oxide nanoparticles with various morphology and sizes were derived via numerical simulations using COMSOL Multiphysics software. The results show the shift of the resonance peak to the infrared region, in contrast to the traditional plasmonic metals, where the resonance peak falls in the visible region. Moreover, metal oxides allow the tuning of plasmon resonance from near to mid-IR region, by varying the size, shape and the doping levels of the nanoparticles. In addition, since the absorption cross-section exceeds both the scattering and the geometrical cross-sections for the particles in sub-wavelength scales, these metal oxide nanoparticles can be utilized as unit cell elements of metamaterials for efficient energy absorption.

Acknowledgment

This work has been supported by PhD Support Program 2021 implemented by the EIF with support of PMI Science and scientific research grants through the Science Committee of MESCS of Armenia (№ 21APP-2J013 and 21DP-2J017).

References

[1] Liu, Juanjuan, et al. "Are plasmonic optical biosensors ready for use in point-of-need applications?." Analyst 145.2 (2020): 364-384.

[2] Hjiri, M., et al. "Al-doped ZnO for highly sensitive CO gas sensors." Sensors and Actuators B: Chemical 196 (2014): 413-420.

Investigation of Opto-Electrical Properties of Original Iridium Metal Complexes

Zommere Margarita Anna[1,*], Dmitrijevs Kirills[2], Sisojevs Žanis[2], Traskovskis Kaspars[2], Kokars Valdis[2], Vembris Aivars[1]

[1] *Institute of Solid State Physics, University of Latvia, Kengaraga Str. 8, LV-1063, Riga, Latvia*

[2] *Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena Str. 3, LV-1048, Riga, Latvia*

[*] *E-mail:* Margarita-Anna.Zommere@cfi.lu.lv

Organic light-emitting diodes (OLEDs) are becoming more widely used in displays due to their pure colour and high efficiency. Second generation emitters are heavy metal-based emitters, which can accelerate the radiative deactivation through phosphorescence from the first triplet state to the ground state and facilitate intersystem crossing from the first singlet state to the first triplet. This process allows phosphorescent emitters to reach 100% of the conversion of excited states into the light and increase OLEDs' external quantum efficiencies. Despite, the high efficiency, OLEDs have a relatively short lifespan. To increase longevity an intramolecular stacking process between the flexibly bridged ancillary aromatic group and the surface of non-ionic iridium (III) complex core was proposed as an approach to obtain phosphorescent OLED second-generation emitters with a reduced aggregation tendency.

In the work, the original Iridium metal complexes were developed, and their light-emitting properties were investigated. Bis[2-(4-(hydroxymethyl)phenyl)pyridinato-C2,N] (picolinato)iridium was used as a base compound where hydroxygroup was functionalized with benzyl succinate (AR415) and ((perfluorophenyl)methyl) succinate (KD29, KD30) groups.

For all the compounds the emission spectra, photoluminescence kinetics and photoluminescence quantum yield were measured in both solutions and thin films. The solutions were made from degassed toluol and host-guest thin films were prepared with 12 wt% of emitters in PVK matrix.

All compounds emit light in the green spectral region. AR415, KD29 and KD30 compounds have up to 90% PLQY in solution and up to 38% in thin films which are promising values for OLED systems.

Finally, OLED with the structure ITO/PEDOT:PSS/TCTA:Emitter/TPBi/LiF/Al were prepared. Emitter concentration in TCTA was 12.5 wt%. The emitter layer was prepared by spin-coating method. The OLED performance in relation to the optical properties of the original Iridium metal complex will be discussed.

The assessment of usability of eye vergence tests for computerized vision screening

Slabcova Jelena[1,*], Eigusa Krista[1], Svabe Angelina[1], Kassaliete Evita[1], Panke Karola[1], Kalnica-Dorosenko Kristine[1], Jansone-Langina Zane[1], Truksa Renars[1], Fomins Sergejs[1], Krumina Gunta[1]

[1] *Department of Optometry and Vision Science*

[*] *E-mail:* jelena.slabcova@lu.lv

Introduction. The uncorrected refractive errors and near vision problems can negatively affect children's academic performance and behaviour [1]. The first symptom of near vision fatigue is the inappropriate work of accommodation and vergence system [2]. Our department works on the development of a computerized vision screening method that can select children with different visual function problems.

Purpose. The study aimed to evaluate the usability of vergence facility (VF) and fusional vergence amplitude (FVA) method based on the random-dot stereogram method for the computerized vision screening.

Method. We tested the computerized vision screening for the evaluation of vergence performance (VF with 4 pd BO and 2 pd BI; breakpoint for crossed and uncrossed FVA) that could be useful for screening at schools, and compared results with the standard optometric methods (12 pd BO and 3 pd BI prism flipper for VF, and prism bar for FVA). 75 subjects (aged 22±5 years) were tested.

Results. Both the evaluation of computerized version for the vergence facility and fusional vergence amplitude showed good repeatability: reaction time for VF 4 pd BO ($F(2,111) = 0.21$, $p = 0.81$) and VF 2 pd BI ($F(2,108) = 1.39$, $p = 0.25$), break point for uncrossed FVA ($F(2,171) = 0.16$, $p = 0.85$) and crossed FVA ($F(2,189) = 1.17$, $p = 0.31$). Additionally, there is not statistically difference between the group's mean values of computerized VF test and standard method ($F(1,110) = 1.53$, $p = 0.25$). However, statistically difference is found between group's mean values of crossed FVA ($F(1,132) = 20.31$, $p < 0.001$) and uncrossed FVA ($F(1,130) = 12.54$, $p < 0.001$) test and classical method.

Conclusion. Our results have demonstrated the usability of vergence facility and fusional vergence amplitude method based on the random-dot stereogram method for screening tests. Technical changes (changes in disparities for VF and control symbols – dynamic markers [3] for FVA) should be made to improve the repeatability of the method.

Acknowledgment

The study is based on project No. KC-PI-2020/10 "Development of vision screening and training equipment".

References

[1] Ali, Q., et al. (2021). Current challenges supporting school-aged children with vision problems: A rapid review. Applied Sciences, 11(20), article No 9673.

[2] Falkenberg, H.K., et al. (2019). Vision status of children aged 7-15 years referred from school vision screening in Norway during 2003-2013: a retrospective study. BMC Ophthalmology, 19(1), article No180.

[3] Rozhkova, G.I., and Vasileva, N.N. (2010). A computer-aided method for the evaluation of fusional reserves with objective control of fusion break. Human Physiology, 36(3), 364-366.

The effect of object shape and location on fixation disparity

Serpa Evita[1,*], Kremera Elizabete Anna[1], Ceple Ilze[1], Krumina Gunta[1]

[1] *University of Latvia, Faculty of Physics, Mathematics and Optometry, Department of Optometry and Vision Science, Riga, Latvia*

[*] *E-mail:* evita.serpa@gmail.com

Fixation disparity is characterized as inaccuracy in vergence eye position during the fixation of a visual target in binocular conditions. Studies demonstrate that fixation disparity can be influenced by testing distance, fixation position [1], as well as the selected background [2]. Fixation parameters play a significant role when calibrating gaze position in video-based eye-trackers, however, most of the eye trackers apply binocular calibration without considering the fixation disparity parameters. Furthermore, fixation targets vary in their shape and size between different eye-tracking systems, as well as within the eye-tracking system itself. Therefore, it is important to evaluate how the selected stimulus may affect the fixation disparity measurements.

The aim of this study was to analyze the effect of target shape and location on fixation disparity. Three different fixation targets were chosen to be tested: (a) the combination of a black circle and white cross which has previously been demonstrated as the target shape providing the most stable fixation position [3], (b) a red dot (0.2 degrees) which is commonly applied in eye movement research [4], and (c) a rabbit face adapted to children eye movement research (nose size 0.2 degrees). The image of the rabbit target was chosen based on studies indicating that children's eye movement research requires meaningful targets [5]. Each of these stimuli was presented in thirteen distinct positions on grey background (RGB 127,127,127) using a flat-panel display. Eye movement recording was performed with Tobii Pro Fusion eye tracker.

The preliminary results demonstrate that the monocular calibration provided by Tobii Pro Fusion system can give information on the monocular gaze point, necessary for fixation disparity analysis. Further studies will reveal the effect of the target shape and position on fixation disparity measurements, and thus, the most appropriate fixation target for eye movement calibration.

Acknowledgement

This work has been supported by the Latvian Council of Science (project Nr.lzp-2021/1-0219), University of Latvia (project Nr. Y5-AZ77-ZF-N-100) and SIA Mikrotikls and the University of Latvia Foundation (project Nr. 2260).

References

[1] S. Jainta & Z. Kapoula, PloS one, 6(4) (2011), e18694.

[2] A. Kopsel & A. Huckauf, Proceedings of the Latvian Academy of Sciences ,71 (2017), p. 359-365.

[3] L. Thaler, et al., Vision research, 76 (2013), p. 31-42.

[4] M. Nyström, et al., Vision research, 121 (2016), p. 95-103.

[5] E. L. Irving, et al., Investigative ophthalmology & visual science, 52(2) (2011), p. 658-664.

The effect of stimulus contrast on saccadic eye movement parameters

Goliskina Viktorija[1], Ceple Ilze[1,*], Truksa Renars[1], Krumina Gunta[1]
[1] *Department of Optometry and Vision Science, Faculty of Physics, Mathematics and Optometry, University of Latvia, Jelgavas 1, Riga, Latvia, LV-1004*
[*] *E-mail:* ilze.ceple@lu.lv

Saccadic eye movements play an important role in the process of human visual perception, which allows to change the fixation points by means of rapid eye jumps [1]. The programming and parameters of the saccades are influenced by both, the stimulus modality (such as auditory or visual signals), as well as by the physical parameters of visual stimulus (e.g. brightness [2], size [3], contrast [4]). The aim of this study is to evaluate the effect of stimulus contrast and direction on saccadic eye movement parameters (latency, accuracy, peak velocity, average velocity and acceleration) and to develop stimuli that are more accurate when studying saccadic eye movements.

IViewX Hi-Speed and Tobii Pro Fusion eye tracking equipment were applied to assess saccadic eye movements. The experiment consisted of horizontally and vertically oriented stimuli of different luminance levels at background luminance of 3, 30 and 90 cd/m2. The stimuli were demonstrated in a random sequence on a computer screen. The participant's task was to perform jump-like movements from the center of the fixation object to the peripheral stimulus.

The research results indicate on a significant effect of the saccade direction on the saccadic measurement of reaction time in the case of positive contrast stimuli (Two-way repeated measurements ANOVA, F (3.12) = 4.605, p = 0.023, np2= 0.535). No significant effect of the saccade direction on the saccadic eye movement accuracy was observed in both the conditions of positive and negative contrast. The main effect of different contrast levels was not observed, unlike the results of other authors [2].

Acknowledgement
This work has been supported by the Latvian Council of Science (project Nr.lzp-2021/1-0219), University of Latvia (project Nr. Y5-AZ77-ZF-N-100) and SIA Mikrotikls and University of Latvia Foundation (project Nr. 2260).

References
[1] Pierce, J. E., Clementz, B. A., & McDowell, J. E. (2019). Saccades: fundamentals and neural mechanisms. In C. Klein & U. Ettinger (Eds.), Eye Movement Research An Introduction to its Scientific Foundations and Applications (pp. 11–72).
[2] Yamagishi, S., & Furukawa, S. (2020). Factors influencing saccadic reaction time: effect of task modality, stimulus saliency, spatial congruency of stimuli, and pupil size. Frontiers in Human Neuroscience, 14. https://doi.org/10.3389/fnhum.2020.571893
[3] Warren, D. E., Thurtell, M. J., Carroll, J. N., & Wall, M. (2013). Perimetric evaluation of saccadic latency, saccadic accuracy, and visual threshold for peripheral visual stimuli in young compared with older adults. Investigative Ophthalmology and Visual Science, 54(8), 5778–5787.
[4] Matsumiya, K., Sato, M., & Shioiri, S. (2016). Contrast dependence of saccadic blanking and landmark effects. Vision Research, 129, 1–12.

Part IV
Poster Session 2

High accuracy measurements and construction of the first triplet state in KCs molecule

Lapins Adams[1,*], Krumins Valts [1], Brakmane Ieva [1], Klincare Ilze[1], Tamanis Maris[1], Ferber Ruvin[1], Stolyarov Andrey[2], Pashov Asen[3]

[1] *Laser Center, Faculty of Physics, Mathematics and Optometry, University of Latvia, 19 Rainis blvd, Riga LV-1586, Latvia*

[2] *Department of Chemistry, Moscow State University, 119991 Moscow, Leninskie gory 1/3, Russia*

[3] *Faculty of Physics, Sofia University, 5 James Bourchier Boulevard, 1164 Sofia, Bulgaria*

[*] *E-mail:* adams.lapins@lu.lv

In present study we focused on the lowest triplet $a^3\Sigma^+$ state of the KCs molecule, which is currently under intensive studies [1] in order to produce the respective ultra cold molecular ensemble. The list of 4500 $c^3\Sigma^+ \rightarrow a^3\Sigma^+$ transitions ($c \rightarrow a$ in short) in KCs molecule was obtained from laser-induced fluorescence (LIF) spectra dispersed by a Fourier-Transform spectrometer IFS125-HR (Bruker), from which 570 lines have been obtained with highest achievable resolution of 0.0063 cm^{-1}. The new data allowed us to fill the gap of transitions to the lowest a-state vibrational levels v_a = 0, 1, and 2 in previous studies. [2,3]. The overall set of available experimental data was used to improve the potential energy curve (PEC) of the $a^3\Sigma^+$ state, particularly near a bottom, providing the refined dissociation energy D_e = 267.21(1) cm^{-1}. The accuracy of the constructed PEC is characterised by deviations between the experimental transition frequencies for a particular LIF progression from the $c^3\Sigma^+$-state rovibronic levels and the respective values calculated from the present $a^3\Sigma^+$ state PEC. The present PEC reproduces the measured transition frequencies within experimental accuracy of the order of 0.003 cm^{-1}. This is substantially better than the deviations in previous studies [2-4], especially pronounced for the lowest vibrational levels. The short range part above the dissociation limit was constructed by matching to the PEC obtained from recorded bound-free transitions [5].

Acknowledgments

We acknowledge support from the Latvian Council of Science Project No. lzp-2018/1-0020.

References

[1] M. Gröbner et. al., Phys. Rev. A **95**, 022715 (2017).
[2] R. Ferber et. al., Phys. Rev. A **80**, 062501 (2009).
[3] R. Ferber et. al., Phys. Rev. A **88**, 012516 (2013).
[4] M. Schwarzer et. al., J. Chem. Phys., **154**, 154304 (2021).
[5] V. Krumins et. al., J. Chem. Phys., **156**, issue 9 (2022).

Development of an optical system for photolithography, utilizing up-conversion luminescence in nanoparticles mixed in photoresist

Vitols Kaspars[1,*], Pervenecka Julija [1], Tropins Ernests[1], Viksna Viesturs Tenis[1], Teterovskis Janis[1], Grube Jurgis[1]

[1] *Institute of Solid State Physics, University of Latvia*

[*] *E-mail:* kaspars.vitols@cfi.lu.lv

It is possible to form lithographic structures in the active substances of organic chemistry, however, when using high-energy - ultraviolet light (UV), unfortunately it is not possible to fully interact with the whole sample. During the exposure, the recording will be made only in the upper layers of the sample. As the surface photoresist layer forms, light is absorbed and prevent interaction with the rest of the sample. To solve this problem, photoactive nanoparticles are added to the volume of the material which emit UV up-conversion luminescence.

A laser diode with a wavelength of 976 nm is used to excite up-conversion luminescence - an anti-Stokes processes where photons with low energy (infrared light (IR)) are absorbed and converted into photons with higher energy (UV). To enchante quality of the sample exposure, additional objects of the optical system are used - an anamorphic prism pair for changing the laser beam profile and objective for focusing beam profile. By changing the parameters of the optical system, different laser beam profiles in the size of 10 to 300 micrometers are obtained. The structure is exposed using the newly acquired laser beam profile. Using the xy stage base as an aid, various linear structures are obtained for the study of the sample. From the obtained results, the system is improved and supplemented, as well as the interaction between the sample and the laser diode beam is studied.

Acknowledgment

This research is funded by the Latvian Council of Science, project "Up-conversion luminescence photolithography in organic compounds using nanoparticles/photoresist composition", project No. lzp-2019/1-0422

Spectral measurements of mercury containing high frequency electrodeless lamps

Rancāne Kristiāna[1,*], Ābola Anda[1], Rēvalde Gita[1]
[1] *Institute of Atomic Physics and Spectroscopy, University of Latvia*
[*] *E-mail:* krir@inbox.lv

In order to be used in the atomic absorption spectrometers, the light sources must meet certain criteria, such as – narrow and intense spectral lines, long lifetime and stability in the time [1].

In this work we measured the intensities of spectral lines for a mercury containing high frequency electrodeless lamp. Spectral lines were recorded in the relative and absolute units and at different generator wattages. Since for the use in atomic absorption spectroscopy (AAS) the "working line" of the mercury in the UV region is 253,7 nm, this line was considered. In addition to intensity measurements, stability of spectral lines was also evaluated for a time period of several hours.

Measurements in the relative units were done by a high-resolution spectrometer Jobin Yvon. For the measurements in absolute units a high-resolution spectrometer Ocean Optics HR4000 was used. In order to measure the absolute intensity correctly, first it was necessary to calibrate the spectrometer using a calibrated deuterium-halogen light source.

Some of the first results are shown in the Fig. 1. It can be observed that as the power increases, the intensity of the 253,7nm spectral line increases exponentially.

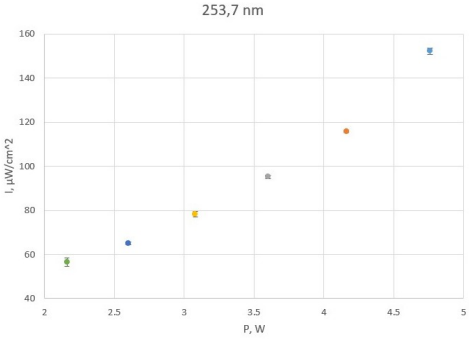


Figure 1: Dependence of absolute intensity of Hg 253,7 nm spectral line on generator operating power in HFEDL.

Acknowledgment
Latvian Council of Science grant No. lzp-2020/1-0005.

References
[1] A.A. Ganeev, Z. Gavare, V.I. Khutorshikov, S.V Khutorshikov, G. Revalde, A. Skudra, G. M. Smirnova, N.R. Stankov, High-frequency electrodeless discharge lamps for atomic absorption. Spectrochemica Acta B 58 (5) (2003) 879-889.

Synthesis of thulium and ytterbium activated NaYF4 nanoparticles for intense up-conversion luminescence

Viksna Viesturs Tenis[1,*], Teterovskis Janis[1], Grube Jurgis[1]
[1] *Institute of Solid State Physics, University of Latvia*
[*] *E-mail:* viesturs@cfi.lu.lv

In this work the process of synthesis of luminescent nanoparticles, which are activated by Tm and Yb ions, will be considered. Rare earth ions ensure that up-conversion luminescence can be observed in the synthesized nanoparticles in the blue and ultraviolet spectral regions when excited with infrared radiation (976 nm). By mixing such synthesized nanoparticles with photoresist, it is possible to expose the photoresist in a volume of material, which allows such a material to be used in photolithography.

The thermolysis method is used for the synthesis of nanoparticles. To perform the work, the nanoparticle synthesis setup was created: a three-necked flask, which is placed in a magnetic heater. For the synthesis process to be successful, most of the synthesis must take place under an argon atmosphere (three vacuum and argon aeration cycles are performed). The nanoparticles growth process takes place at 300 ℃ whereby changing the heating time it is possible to grow nanoparticles with different sizes. Synthesized nanoparticles can be characterized by the Core and Core+Shell structure to obtain the desired spectral properties. Nanoparticle sizes are determined by the electron microscopy. Up-conversion luminescence spectra in the blue and ultraviolet spectral regions were measured for the synthesized samples, excited by infrared radiation (976 nm) to compare luminescence bands ratios.

Acknowledgment
This research is funded by the Latvian Council of Science, project "Up-conversion luminescence photolithography in organic compounds using nanoparticles/photoresist composition", project No. lzp-2019/1-0422

Use of Yb3+ and Tm3+ activated nanoparticle up-conversion luminescence in photolithography, for optical writing in the structure of negative photoresist SU8

Tropins Ernests[1,*], Pervenecka Julija[1], Vitols Kaspars [1], Viksna Viesturs T.[1], Teterovskis Janis [1], Vembris Aivars [1], Butikova Jelena [1], Grube Jurgis [1]
[1] *Institute of Solid State Physics, University of Latvia*
[*] *E-mail:* ernests.tropins@cfi.lu.lv

The creation of an organic light-emitting microstructure by photolithography using negative-tone photoresists has been practically impossible, but now there is a possible solution. Up-conversion luminescence is a process that occurs in materials activated with rare-earth ions, when they are optically excited, which results in emission of radiation with an anti-Stokes offset in relation to excitation radiation. It could be used to overcome the main obstacle in the creation of organic light emitting microstructures and solve a problem with traditional exposition.

Traditional exposure happens by exposing a sample to UV radiation through its surface, but this kind of exposure is limited by the thickness of photo sensitive layer. In thick samples (more than 10 um) most of the radiation is absorbed in the upper layers, which results in unexposed deeper layers. Mixing the photoresist with nanoparticles activated with rare-earth ions, in which up-conversion luminescence occurs, would solve the issue, because exposure would happen in the whole volume of a sample and all the photoresist would be exposed.

Similarly, up-conversion luminescence could be used to expose a photoresist mixed with organic chromophores. This kind of a mixture cannot be exposed traditionally, because of chromophore high absorption of UV radiation normally used in photolithography. However, if up-conversion luminescence nanoparticles are introduced, radiation which is absorbed less could be used to excite the nanoparticles and exposure would happen throughout the volume of a sample.

In this work a system of SU8 photoresist mixed with up-conversion luminescence nanoparticles was created and studied. Optical writing was done by using a 976 nm laser diode to excite up-converting nanoparticles. Further a 3 part system (photoresist, nanoparticles, organic chromophore) will be created. The viability of using such a system to create light emitting microstructures for use in medicine, telecommunication or other industries will be discussed.

Synthesis and optical properties of $MgGeO_3$:Cr^{3+} nanoparticles

Kalnina Aija[1,*], Doke Guna[1], Butikova Jelena[1]
[1] *Institute of Solid State Physics, University of Latvia*
[*] *E-mail:* aija@cfi.lu.lv

Persistent luminescence has wide range applications, luminophores are used in bioluminescent markers, light sources, agronomy, electronics and so on. Red and infrared persistent luminescence has been studied for applications in medicine for diagnostics and therapy methods [1], [2].

One of the transition metal ions that can provide persistent afterglow in the red and near-infrared spectral range with the appropriate host material is Cr^{3+} impurity ions. Cr^{3+} is studied in different host materials for example in gallates, aluminates, germinates. In this research, we are investigating Cr^{3+} ions activated $MgGeO_3$ material. We have described luminescence properties for $MgGeO_3$:Cr^{3+} micro powder sample, but for applications we usually need persistent luminescent nanomaterial, so then next step in this study is to make $MgGeO_3$:Cr^{3+} nanoparticles and measure its luminescence properties.

In the course of this study $MgGeO_3$:$^{3+}$ micro powder sample with Cr^{3+} concentration of 0.25 mol %, was prepared by high temperature solid state reaction and from micro powder tablets nanoparticles were made using laser ablation method in liquid. The material properties of $MgGeO_3$:Cr^{3+} nanoparticles were investigated by SEM, X-ray diffraction, excitation and emission spectra, afterglow spectra etc. Material excited by X-rays or UV exhibit intense persistent infrared luminescence with a peak around 780 nm. Based on obtained results, conclusions about $MgGeO_3$:Cr^{3+} nanoparticles luminescence has been drawn.

References

[1] Y. Liu and B. Lei, Persistent Luminescent Materials, in Phosphors, Up Conversion Nano Particles, Quantum Dots and Their Applications, Singapore: Springer Singapore, 2016, pp. 167214.
[2] J. Liu, T. Lecuyer, J. Seguin, et al., "Imaging and therapeutic applications of persistent luminescence nanomaterials", Advanced Drug Delivery Reviews, 2019., 138, 193-210.

Through-space and metal-assisted charge transfer in carbene-metal complexes

Stucere Kitija A.[1,*], Ruduss Armands[2], Traskovskis Kaspars[2], Vembris Aivars[1]

[1] *Institute of Solid State Physics, University of Latvia, Kengaraga Str. 8, LV-1063, Riga, Latvia*

[2] *Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena Str. 3, LV-1048, Riga, Latvia*

[*] *E-mail:* kitijaalise@gmail.com

Materials for organic light-emitting diodes could be divided into several generations were last 3rd generation organic compounds exhibiting TADF which exhibit up to 100% singlet and triplet state conversation to light without the presence of heavy metal. Organometallic complexes consisting of Cu metal atom is a conceptually different class of low-cost TADF emitters. While this element does not exhibit fast room-temperature phosphorescence, it still can promote a rapid TADF, despite the considerable ΔE_{ST} gaps met in such compounds (> 0.05 eV).

In this work, we present a novel approach towards TADF emitters where charge transfer through-space and metal-assisted take place. Cu complexes bearing carbazolide and carbene ligands were synthesized. Imidazole-based N-heterocyclic carbenes (NHCs) were used, with electron-accepting sulphonyl groups introduced at 4-position of the N-bound 2,6-diisopropylphenyl (Dipp) substituents.

Photoluminescence bands, decays and quantum yields of complexes in various solutions, as well as PMMA-doped films with emitter concentration 5 wt%, were taken. Photoluminescence quantum yield from 0.2 to 0.3 was obtained in solutions but in thin films, it increased up to 0.9 due to the decreased torsional degree of freedom.

Emission properties of thin films in the temperature diapason from 10 to 300 K were measured to estimate the charge transfer mechanism. Emission decays could be described by three exponential functions in all temperature intervals. One featuring a prompt and two delayed emission components. For both delayed emissions, the fastest and slowest emission rate decrease is observed throughout the cooling range, designating a thermally activated nature of the emissive process. The corresponding ΔE_{ST} values were estimated from Arrhenius plots and are in the range of 0.0062 - 0.0075 eV. By combining through-space CT architecture, giving compounds the characteristic low ΔE_{ST} values, with the presence of a heavy metal atom, which provides small, but still present SOC.

Optical properties of near infrared persistent phosphor $CaZnGe_2O_6:Cr^{3+}$, M^{3+} (M^{3+} = B^{3+}; Al^{3+}; Ga^{3+})

Doke Guna[1,*], Kalnina Aija[1], Springis Maris[1], Sarakovskis Anatolijs[1]
[1] *University of Latvia, Institute of Solid State Physics*
[*] *E-mail:* guna.doke@gmail.com

The persistent luminescence, sometimes called afterglow luminescence and long-lasting phosphorescence, is a process characterized by emission of light for a long period of time, usually tens of minutes or more after the removal of the excitation source, that has aroused widespread interest among scientists and industry for the past two decades.

Currently in the literature it is possible to find several hundred combinations of materials and activators that exhibit persistent luminescence, however vast majority of studies are devoted to persistent luminescence processes in the visible part of the spectrum. Moreover, the ions of rare earth elements are mainly used as activators. In recent years due to their potential application in some advanced fields, such as optical data storage, night-vision surveillance, solar energy utilization, anti-counterfeiting and especially bio-imaging, drug delivery and therapy, considerable attention has been paid to near-infrared (NIR) persistent phosphors [1],[2].

As one of the most promising activator for NIR emission, trivalent chromium is often mentioned. By choosing different host materials, one can obtain Cr^{3+} luminescence and afterglow in the spectral range from 650 to 1200 nm.

In the course of this work, $CaZnGe_2O_6:Cr^{3+}$, M^{3+} (M^{3+}=B^{3+}; Al^{3+}; Ga^{3+}) materials have been synthesised by a melt crystallization method. Photoluminescence and subsequent persistent luminescence of chromium ions in the NIR spectral region as well as visible photoluminescence and afterglow of host material have been observed. After irradiation with ultraviolet radiation, broad NIR persistent luminescence band with a maximum around 790 nm and an afterglow time over 1 h has been observed. Addition of B^{3+}; Al^{3+} and Ga^{3+} increases overall intensity and duration of persistent luminescence. The analysis of persistent luminescence decay curves and glow curves of thermally stimulated luminescence were used to analyse the nature of the trap centres and discuss mechanism of persistent luminescence.

Acknowledgment

Financial support provided by Latvian Council of Science Grant No. LZP-2019/1-0443 is greatly acknowledged. Institute of Solid State Physics, University of Latvia as the Center of Excellence has received funding from the European Union's Horizon 2020 Framework Programme H2020-WIDESPREAD-01-2016-2017-TeamingPhase2 under grant agreement No. 739508, project CAMART [2]

References

[1] Ma, C. et al. The Second Near-Infrared Window Persistent Luminescence for Anti-Counterfeiting Application. Cryst. Growth Des. 20, 1859–1867 (2020).
[2] Kamimura, S. et al. Near-infrared luminescence from double-perovskite Sr3Sn2O7:Nd3+: A new class of probe for in vivo imaging in the second optical window of biological tissue. J. Ceram. Soc. Japan 125, 591–595 (2017).

Light-emitting electrochemical cells with carbazole derivatives with pyridinium ions as emitters

Maurucaite Adriana[1], Leduskrasts Kaspars[2,*], Suna Edgars[2], Vembris Aivars[1]
[1] *Institute of solid state physics, University of Latvia*
[2] *Latvian institute of organic synthesis*
[*] *E-mail:* adriana.maurucaite@cfi.lu.lv

Light-emitting electrochemical cells (LEC) are relatively easy-to-fabricate thin-film lighting devices. Therefore, LECs have been already successfully used in high-end smart lighting applications such as light-emitting clothes and emissive textiles, rollable and stretchable wallpaper-like lamps, and biocompatible light sources for in vivo or epidermal medical devices. However, most of the LECs utilise ionic metal complexes as emitters that consist of the rear element Iridium. Ionic small molecules (SM) as light emitters could be a better solution to the low-coast device.

In the work, we have investigated purely organic ionic compounds that could exhibit aggregate induced emission. The compounds consist of the carbazole group and pyridinium ion as a cation. Perchlorate was used as an anion. Emission spectra, fluorescence kinetics and photoluminescence quantum yield (PLQY) were measured in polymer doped thin films. Polymethyl methacrylate and polyethylene oxides were used as polymers. Al compounds emitted light from 400 to 550 nm range with the PLQY up to 50%. Time-resolved spectroscopy revealed two processes with the time constant of few and a few hundred nanoseconds while no changes in the emitted light spectra were observed. From this, it can be concluded that in all cases there is the same proposed condition, which is populated through different mechanisms. In the end, LEC cells with the simple structure ITO/PEDOT:PSS/Emitter/Al were prepared and investigated. The detailed results discussing the impact of the molecule structure and chosen polymers on the optical and LECs properties will be presented.

Approbation of color vision test for computerized vision screening protocol

Letko Ksenija[1,*], Jansone-Langina Zane[1], Truksa Renars[1], Kassaliete Evita[1], Slobcova Jelena[1], Fomins Sergejs[1], Kalnica-Dorosenko Kristine[1], Panke Karola[1], Krumina Gunta[1]

[1] *University of Latvia, Faculty of Physics, Mathematics and Optometry, Department of Optometry and Vision Science, Riga, Latvia*

[*] *E-mail:* jansonezane1993@gmail.com

Introduction: It is important to detect color vision defects in childhood before the child goes to school. Unknown color vision deficits can reduce learning abilities which include color symbols, tasks. The main purpose of color vision screening is to assess the existence of a deficiency, inform parents and help the child find adaptive strategies and take them into account when planning for a future profession. [1,2] Our aim was to perform approbation of a vision screening computerized color vision test and evaluate its suitability for color vision defects detection.

Method: In our research participated 75 patient (18–45 years). All the participants were employees and students of the University of Latvia. We measured color vision sensitivity with computerized color vision test and compared the results with Hardy-Rand-Rittler (HRR) test findings. Tests were done binocular, at 40 cm, daily light conditions. All the tests were analyzed with Student's t-test.

Results: Computerized color vision test detected color vision deficits to 10,81% participants (tritan - 5,41%; deutan - 2,70%; protan - 2,70 %). HRR tests results showed that 2,70% participants have color vision deficiency (protan - 2,70%). Patients who failed in HRR did not showed color vision deficiency at vision screening color vision test and vice versa. Conclusion: The results show that computerized color vision test results don't match HRR test results which can be explained with uncorrected lighting conditions. Tests should be done in scotopic conditions.

Acknowledgment

The research is being supported by LIAA and LU project no. KC-PI-2020/10 "Development of vision screening and training equipment". The author Zane Jansone-Langina is financial supported by SAM project (Grant.nr. Nr.8.2.2.2. /18/A/010; registration nr. ESS2018/289)

References

[1] Jadhav, Sg, Kundu, S. (2017). Importance of colour vision testing in school-based eye health examination. Community Eye Health, 30(98), S24–S25.

[2] Pfäffli, O. A., Tamási, B., Hanson, J., Gerth-Kahlert, C. (2020). Colour vision testing in young children with reduced visual acuity. Acta Ophthalmologica, 98(1), e113-e120.

Smooth pursuit eye movement evaluation with ramp and step-ramp visual stimuli

Volberga Liva[1,*], Krauze Linda[1], Ceple Ilze[1], Truksa Renars[1], Krumina Gunta[1]
[1] *University of Latvia, Faculty of Physics, Mathematics and Optometry, Department of Optometry and Vision Science*
[*] *E-mail:* liva.volberga@lu.lv

Smooth pursuit eye movements ensure projection of a slowly moving target image on the fovea. [1] To assess smooth pursuit eye movements two types of stimuli (*ramp* and *step − ramp*) are applied. In the case of a *ramp* visual stimulus the smooth-pursuit stimulus starts the motion from the same position as the fixation cross was located right before the stimulus demonstration. [2] In the case of a *step − ramp* stimulus the smooth-pursuit moving stimulus is placed eccentrically and then starts moving towards the previous fixation position and continues the movement further. [3] The aim of the current research work is to explore how different parameters (position, direction) affect smooth pursuit eye movement performance.

Black (RGB 0,0,0), 1 degree large *ramp* and *step−ramp* visual stimuli were presented on a 33 cd/m^2 bright, grey (RGB 114,114,114) monitor at a viewing distance 65 cm. The stimuli moved horizontally and vertically at a speed of 15 degrees per second. 0,5, 1, 1,5 and 2 degree steps from the fixation cross were applied in the *step − ramp* stimuli. Eye movements were recorded using a Tobii Pro Fusion eye movement recorder and analysed using a Tobii Pro Lab system.

The results demonstrate no statistically significant displacement effect on the latency results neither in vertical direction ($F(4, 30) = 0.76$, $p = 0.56$), nor the horizontal direction, ($F(4, 30) = 0.313$, $p = 0.87$) (One-way ANOVA). In vertical *step−ramp* stimuli no catch-up saccades were observed with a 1,5 degree shift from the fixation cross, while in horizontal *step − ramp* stimuli no catch-up saccades were observed with a 1 degree shift from the fixation cross.

Acknowledgment
This work has been supported by the Latvian Council of Science (project No. lzp-2021/1-0219), University of Latvia (project Nr. Y5-AZ77-ZF-N-100) and SIA Mikrotikls and University of Latvia Foundation (project Nr. 2260).

References
[1] Salman, M.S., Sharpe, J.A., Lillakas, L., Dennis, M., & Steinbach, M.J. (2006). Smooth pursuit eye movements in children. Experimental Brain Research, 169, 139-143.
[2] Robinson, D.A. (1965). The mechanics of human smooth pursuit eye movements. Journal of Physiology, 180, 569-591.
[3] Ciuffreda, K.J., & Tannen, B. (1995). Eye Movement Basics for the Clinicians. Mosby.

Stereovision and reading difficulties

Parfjonova Aija[1,*], Serpa Evita[1], Ceple Ilze[1], Krumina Gunta[1]

[1] *University of Latvia, Faculty of Physics, Mathematics and Optometry, Department of Optometry and Vision Science, Riga, Latvia*

[*] *E-mail:* aija.parfjonova@gmail.com

Introduction. Reading is the ability to accurately perceive, recognize and interpret the written form of a language a process that a person begins to learn at preschool age. During reading, both eyes are guided and controlled by the oculomotor and sensory process of the visual system, which is responsible for the sequential transfer of the direction of view from word to word, which alternates with a relatively calm state of the eyes – fixations. Fixations are necessary for the visual system to be able to perceive the visual information.

More than 100 years ago, reading fluency was thought to depend primarily on human visual functions and visual memory [1] and on visual processes that take place at the neural level [2]. Today, these perceptions have changed, and children with reading difficulties often have genetic and phenotypically complicated neurological disorders affecting 5-10% of school-age children [3]. At the same time, there are several studies showing an association between reading difficulties and impaired binocular vision functions [4] including the quality of stereo vision [5].

The aim of this study is to evaluate the relationship between the amount of fixation disparity and the quality of stereo vision in different gaze positions on the screen and the reading eye movement parameters.

Method. As part of the study, the Tobii Pro Fusion eye tracker will evaluate eye movement parameters during text reading. In addition, (1) fixation disparity and (2) stereo depth of field resolution will be evaluated in different areas of the screen.

Conclusions. Literature analysis shows that eye movements during reading provides important information about the perception of information in the written text and its analysis. Fluent movement or abnormalities, gives an idea of the general functions of the visual system and, if necessary, allows the specialist to prescribe further therapy or control.

Acknowledgment

This work has been supported by the Latvian Council of Science (project Nr.lzp-2021/1-0219), University of Latvia (project Nr. Y5-AZ77-ZF-N-100) and SIA Mikrotikls and the University of Latvia Foundation (project Nr. 2260).

References

[1] J. Hinselwood. The Lancet, 146 (1895), p.1564-1570.
[2] S.T. Orton. Archives of Neurology and Psychiatry, 14 (1925), p.581-615.
[3] S. K. Katusic et al. Mayo Clinical Proceedings, 76 (2001), p.1081-1092.
[4] M.P. Bucci. Graefes Archive for Clinical and Experimental Ophthalmology, 246(3) (2008), p.417-428.
[5] M.T. Kulp & P.P. Schmidt. Optometry and Vision Science, 73(4) (1996), p.255-262.

The use of computerised vision screening equipment for vision training

Kalnica-Dorosenko Kristine[1,2,*], Vaitaite Rebeka[1], Panke Karola[1], Truksa Renars[1], Krumina Gunta[1]

[1] *Department of Optometry and Vision Science, Faculty of Physics, Mathematics and Optometry, University of Latvia, Jelgavas 1, Riga, Latvia, LV-1004*

[2] *Eye Diseases Clinic, Children's Clinical University Hospital, Vienibas gatve 45, Riga, Latvia, LV-1004*

[*] *E-mail:* kristinekalnica@gmail.com

Introduction. Accommodation and binocular vision problems are the most common visual disorders in the clinical population, except for refractive errors (Jiménez et al., 2004). Vision training is also known as vision therapy, which involves exercises to improve vision and return vision as close as possible to a balanced visual system. Nowadays, computerised programs for training and restoring visual functions are increasingly used due to their entertainment factor and their interesting and attractive design. With the changing environment and the various possibilities to carry out vision exercises remotely, in consultation with a vision specialist, the interest in computer-based vision training is growing. Hence, the aim of the present study is to evaluate the effectiveness of a newly developed computer-based vision training program in home-based vision therapy.

Method. The participants are 22 neurologically healthy subjects aged 22-27 years (mean age 22 $\pm$ 1 year). Before and after the vision training, participants were tested on visual functions such as accommodation facility, near and recovery point of convergence, vergence facility, fusion reserves, and strabismus angle (Maddox Rod Test). In the computer-based program, a method based on the principle of the scattered point was used to train the fusion and vergence functions. Participants in the study had to carry out daily vision training at home for a month using red-blue light filters.

Results. At the moment, seven people have completed the home computer therapy. One participant dropped out due to computer problems and two couldn't continue due to eye pain during training. The results show a statistically significant improvement in VF p¡0.05, however, no improvement in AF p=0.08, NPC and RPC p=0.22, FR at far BI double point p=0.42, recovery point p=0.44; with BO double point p=0.16, recovery point p=0.13. FR at near BI double point p=0.48, recovery point p=0.35; with BO double point p=0.35, recovery point p=0.33; MRT at far p=0.50, at near p=0.35.

Conclusion. For more precise conclusions, a high number of participants who have completed visual training is needed.

Keywords: fusions, fusion mechanism, fusion reserves, vergence facility, vision training

Acknowledgment

The study is developed by LIAA and the University of Latvia within the project No KC-PI-2020/10 "Development of a vision screening and training equipment".

ISBN 978-9934-23-624-2

WWW.DOCRIGA.LV

SPIE. STUDENT CHAPTER UNIVERSITY OF LATVIA

UNIVERSITY OF LATVIA

UNIVERSITY OF LATVIA
INSTITUTE OF ATOMIC PHYSICS AND SPECTROSCOPY