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The project „FOTONIKA-LV – FP7-REGPOT-CT-2011-285912” – the second year scientific outcomes

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Book of abstracts

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Unlocking and Boosting Research Potential for Photonics in Latvia - Towards Effective Integration in the European Research Area (FOTONIKA-LV)
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INTRODUCTION

The abstract book for the section of the 72nd Annual Scientific Conference of the University of Latvia:
“The project „FOTONIKA-LV – FP7-REGPOT-CT-2011-285912” – the second-year scientific outcomes” highlights the main achievements of the project aimed to unlock and boost the Latvian R&D potential for photonics, quantum sciences and technologies at the University of Latvia .
The direct beneficiary of the project - the FOTONIKA-LV Association was founded on April 24, 2010 by the Institute of Atomic Physics and Spectroscopy, the Institute of Astronomy and the Institute of Geodesy and Geoinformatics involves now more than 120 researchers and students (from BsC to MsC and PhD level) including 6 repatriated and 6 recruited from abroad experienced researchers.

Enhancement of research and outreach activities cover various fields of photonics: optics, optoelectronics; in atmosphere and space; Earth geodesy; laser ranging and remote sensing; atomic, molecular, and ion physics; laser spectroscopy, bio-photonics and medical physics.

Oral presentations and posters will provide comprehensive insight into the efforts of the FOTONIKA-LV community current research activities during the years 2012-2013, measures related to corporate responsibility and persistent efforts to ensure sustainability by new project proposals. Despite the degrading impacts on the Latvian RTD sector of the overall financial crises the researchers of the three institutes demonstrate the will and capacity to transform the National research centre of the FOTONIKA-LV Association into a remarkable and essential player in the photonics domain of the European Research Area.

Dr. Arnolds Ubelis

Scientific Secretary of the Association FOTONIKA-LV

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Look back at the Biophotonics Riga 2013 conference

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The University of Latvia has positioned itself within the biophotonics sector of Baltics and, therefore, started series of regular international events on Biophotonics including training course for young researchers + conferences + exhibitions for high-tech SMEs.

The mission of the 1st International Conference "Biophotonics - Riga 2013", Exhibition for high-tech SMEs from Estonia-Latvia-Lithuania, and Training course for young researches was sharing knowledge in biophotonics not only in Baltic countries and Europe but also on global scale given the invited lecturers from Australia and New Zealand. The events co-funded by the European Commission were held in Riga on August 26-31, 2013 (www.lu.lv/fotonika-lv/realizetie-projekti/regpot-2011-1/konferences/biophotonics-riga-2013).

The main topics of the conference and training course included:

- Biophotonic Environmental Sensors;
- Biophotonic Medical Sensors;
- Challenging Problems of Biophotonics.

The event commenced with a training course for young researchers which was attended in total by 36 young researchers and about 15 other conference participants. An open Call for Abstracts was launched to facilitate participation of young researchers and the best ones were granted participation expenses covering travel, accommodation, and subsistence. Selection was made by International Project board on the basis of the scientific profile of candidates in accordance with principles of equal opportunities among candidates.

Similarly, an open Call for Exhibits by SMEs form Baltic countries was launched to facilitate participation of high-tech SMEs; the best ones were granted participation expenses covering travel and exhibit transport, accommodation and subsistence.

The 95 conference participants from 17 countries followed 18 plenary and 18 lectures on training course, 22 presentations of young scientists and 29 posters; 10 exhibits were from Baltic countries as well as promotion provided by sponsors OSA & SPIE.

The Conference confirmed the growing role of Biphotonics technologies - the hottest topics of the field were reviewed by internationally recognised experts: J.Popp (DE), D.Sampson (AU), S.Andersson-Engels (SE), S.Svanberg (SE), and others. Students' feedback collected and analysed confirms success of the 3-day training course. The conference concluded that discussed knowledge has to be disseminated to researchers and companies in the Baltic countries by help of the Baltic Photonics Cluster. Participants expressed interest to meet again, supporting Biophotonics-Riga as a regular event.

Fig.1. Biophotonics Riga-2013 participants

Riga Photonics Centre – Key to awareness about Photonics

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Riga Photonics Centre (RPC) is WP5 of the FOTONIKA-LV project. RPC is public access place in Riga with aim to promote photonics in Latvia, contribute with photonics industry and increase public awareness about optics and photonics.

RPC gets involved in national scientific public policy development to elevate photonics as a National RTDI priority.

RPC has launched web-page *www.lu.lv/fotonika-lv*, where activities of the project are reflected. The web-page is linked to participating institutes and groups detailed information.

Large public photonic related events and mid-sized demonstrations take place at the RPC. RPC participates in national (Scientists Night) and other scientific and public events (seminars, international co-operation, video in RPC window), as well as with the mass media (TV, the Internet, printed)

To increase interest about photonics among students and society in general there is exposition in the RPC which covers 9 topics of optics – colours, diffraction, polarisation, reflection, interference, fluorescence, infrared and ultraviolet radiation, gas discharge and lasers. Results of public awareness were presented in ETOP 2013 Conference, Porto, Portugal. Overall around 300 students visited RPC during 2012 and 2013.

RPC organized The First Regional Workshop – Inventory of Capacity: Human Resources, Industry, Intellectual Capacity and IPR in July 2013 and The First Regional Forward-Looking Innovation and IPR Workshop in December 2013.

Progress in the processing of scans of Schmidt telescope astronomical plates

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Scanned image dimensions of one photos is 21640x21644 pixels, and takes ~920Mb. For the data processing the standard IRAF (Image Reduction and Analysis Facility) program package was fitted. Due to different photo plane curvature distortions occur in the field corners. To solve this problem, a computer code determining celestial coordinates of stars was written. Fitted program calculates the plane solutions by iterations, starts from the centre and go on increasing radius, until it reaches the edge of field. The program automatically calculates corrections between different apertures. FWHM (Full width at half maximum) varies from 5 to 6.5 pixels. The magnitudes of stars were obtained using multi-aperture photometry. The size of the aperture depends on FWHM of the stars. The program automatically calculates corrections between different apertures results being calculated for the largest aperture used. Then the instrumental catalogue was compared to a standard catalogue (UCAC4) (see Fig.1.). The mean accuracy of the coordinate determinations in the entire field is 0.5 of a pixel. As a result we got two catalogues: One with corrected colour equation (includes calculated dependence from B-V). But in this case it can be done only for the stars with a known index B-V. Another catalogue contains all detected object but doesn't has colour index correction. As in most cases, variable stars do not have a known index B-V, they can only be found in this catalogue.

Fully analytical solution for photographic magnitudes reductions to the standard system was obtained by testing. One possibility is to use high accuracy CCD measurements, which is now becoming available in a new online astrometrical data. These new whole sky catalogues could be used for both purposes - astrometrical and photometrical Schmidt telescope plate solutions.

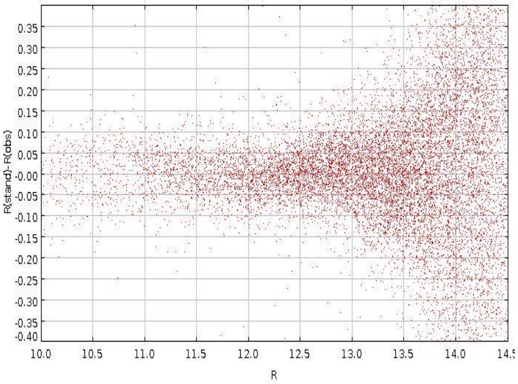

Fig.1. Comparison of the obtained and UCAC4 catalogue R magnitudes.

Upgrade and Defining the Profile of the Riga SLR Station

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Currently The Riga SLR station is the most northern station continuously operating in the global laser-ranging Network. However, due to aging the hardware and software of it has become obsolete or underperforming and, as a result, the data output has reduced during the last years, particularly of the high-orbiting satellites like LAGEOS and of the GNSS constellation.

In order to continue operating and to produce a scientifically useful output the hardware and software need to be upgraded, the operational procedures improved and modernised and the quality controls strengthened.

The paper describes evaluation of the existing equipment and the most advantageous achievable operation mode under the given circumstances. The operational profile and specialisation of the station should be redefined to ensure the importance of Riga Station in the SLR community for the next 10-15 years.

The minimum requirements are identified as:

- Hardware and software upgrade to restore daylight tracking and reach full round-the-clock capability increasing the total annual amount of SLR observations at a consistent level of data quality.
- To achieve regular observations of LAGEOS (day/night) and GNSS (initially only at night) to reach the full ILRS operational goals for high satellites.
- Participation in laser ranging of the space-debris in conjunction with other European SLR stations.

The upgrade of the Riga SLR station comprises three stages. The first stage includes renovation of tracking the high-orbiting satellites, replacement of the time and frequency basis, improvements of the existing software and system maintenance, updating and verifying the existing mount model parameters and collecting data about mount and monument stability. This stage is planned to be completed in 2014. In the second stage improvement of the receiver path efficiency is planned by adding a CCD camera for visual tracking and switching between alternative detectors, e.g., the PMT and avalanche diodes. In the third stage improvements of the telescope tracking system will be made to full utilisation of angular decoders and advancement of tracking automation.

The progress is already made in recovering the LAGEOS/GNSS tracking capabilities - first results were obtained in autumn 2013 after complete realignment of the optical system of the telescope. Currently the upgrade of time and frequency service is under way including installation of a GPS disciplined rubidium oscillator and fibre optics for reference frequency distribution. Other activities include installation of angular encoders on the telescope axes, improving the telescope mount model, monitoring its deformation and introducing a close control loop of the telescope control by the next generation control software.

Quality control monitoring includes spreadsheet applications developed by one of the authors in GFZ for the Potsdam SLR station.

Further modifications and specialised upgrades are intended to participate in the space-debris observations. All the upgrades should be compatible with the further developments expected in future, such as installation of multiple photon detector receiver configurations (PMT/Diode) or installation of a high repetition rate (kHz) laser.

Peculiarities of the Formation of Bright and Dark States at Hyperfine $3D_{3/2}$ and $3D_{5/2}$ Levels of Sodium

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We discuss formation of the bright and dark states in a generalized ladder scheme [1] of three hyperfine (HF) manifolds upon coupling by a strong laser field. We investigate the typical Autler-Townes type excitation schemes, where a weak probe field is used at the first excitation step between the 3S1/2 and 3P3/2 states, while a strong field further couples the 3P3/2 to the 3D3/2 (or 3D5/2) states in Na. We perform numerical simulations for population of the final state in the ladder scheme as a function of the weak probe field detuning under different coupling field parameters, e.g., detuning and intensities. Depending on the number of the involved HF levels, the coupling by a sufficiently strong laser field can lead to formation of only bright or bright and dark states. A peculiar behaviour of the fluorescence intensities of the bright states, upon increase of the coupling field strength, is observed depending on weather the final state in the ladder scheme is the 3D3/2 or the 3D5/2 state. In the 3D3/2 case the intensities of the outermost bright peaks diminish until their full dissapearance with sufficiently strong coupling field, while in the 3D5/2 case the intermediate bright states dissapear and the outermost ones survive. This observation is confirmed by calculations of the dressed-states eigenvalues which match positions of the bright and dark peaks. In preparation for experimental demonstration of the above effects, reallistic parameters, e.g. extending of the transit time, are included in our theoretical model and the best parameters for conducting the experiment are investigated.

This works was carried out withtin the EU FP7 Centre of Excellence project "FOTONIKA-LV–FP7-REGPOT-CT-2011-285912". Partial support by the EU FP7 IRSES project COLIMA, as well as the trilateral grant of the Latvian, Lithuanian and Taiwanese (LLT) Research Councils are acknowledged.

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Radiofrequency-Induced Förster Resonances in Cold Rb Rydberg Atoms

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We studied the radiofrequency-induced Förster resonances in cold Rb Rydberg atoms in a magneto-optical trap. Förster resonances occur due to dipole-dipole interaction between Rydberg atoms if the atoms are laser-excited to a level that lies midway between two other levels of the opposite parity [1]. This process is resonantly enhanced at a zero energy defect between the initial and final collective states of two interacting Rydberg atoms, which can be tuned by weak electric field [Fig.1(a)]. In our experiments we excite cold Rb atoms to the initial 37P state. In the dc electric field of 1.79 V/cm there is a single Förster resonance 37P+37P→37S+38S and Rydberg atoms in the final state 37S can be detected. Our detection system based on selective field ionization provides atom-number resolved measurements for 1-5 detected Rydberg atoms [1].

If we admix a radiofrequency (rf) electric field to the dc electric field, it can induce additional Förster resonances [2,3] as shown by green arrows in Fig.1(a). The rf photons compensate for the energy defect of the Forster resonance and induce additional resonances, which correspond to the induced absorption or emission of rf photons. If the rf amplitude is large enoug, it can even induce multiphoton trasitions of high orders. Note that rf field drives the transitions not between Rydberg states (typical frequencies 10-100 GHz) but between nearly degenerate collective states of a quasimolecule formed by the interacting Rydberg atoms (typical frequencies 10-100 MHz).

We have performed experiments with Rb(37P) atoms interacting in a small laser excitation volume of a cold atom cloud. Fig.1(b) demonstrates a typical record of the rf-induced Förster resonances for 1-5 detected Rydberg atoms at 20 MHz. The peculiarities of rf-induced Förster resonances will be discussed in this report.

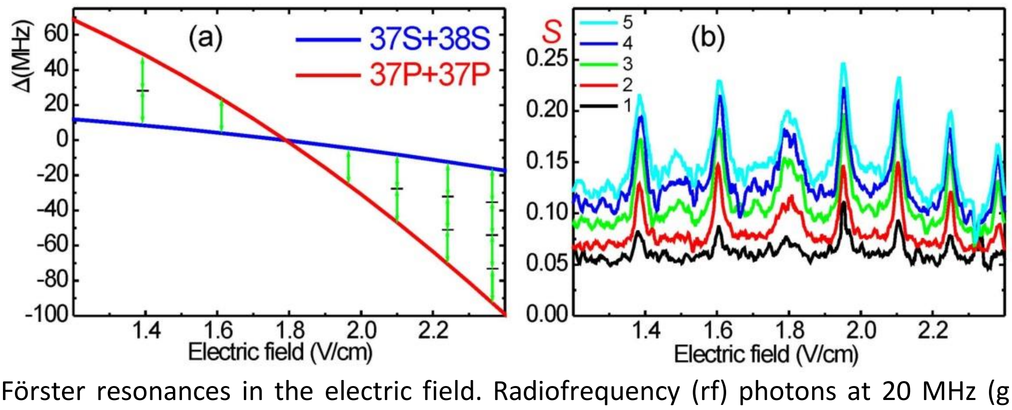

Fig.1. (a) Förster resonances in the electric field. Radiofrequency (rf) photons at 20 MHz (green arrows) induce additional resonances. (b) Experimental record of the rf-induced Förster resonances for 1-5 detected Rydberg atoms.

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Penning Ionization of Two Rydberg Atoms

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Ionization dynamics due to Rydberg atom interactions plays an important role in the evolution of ultracold plasmas [1]. Electron emission resulting from collisions of two Rydberg atoms can occur via two mechanisms: associative (AI) and Penning ionization. The AI is a short-range process that requires overlap of valence electron wavefunctions of both atoms. The PI, in contrast, is a long-range process which can occur at large internuclear separations $R >> n^2$, where *n* is the principal quantum number (atomic units are used).

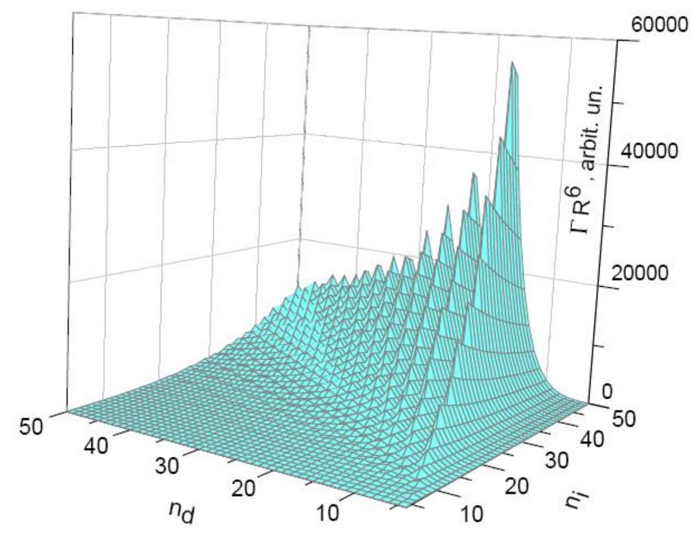

Fig.1. autoionization width $\tilde{\Gamma} R^6$ of two hydrogen Rydberg atoms with the orbital quantum numbers $l_d = l_i = 1$ as a function of principal quantum number of both atoms.

We consider coupling between two ultraocold hydrogen Rydberg atoms using the model of dipole-dipole interaction, assuming that ionization occurs in an Auger type process. This presumes that one atom undergoes a transition $n_d, l_d \to n'_d, l'_d$ to a lower state, while the other atom uses the released energy to undergo a transition $n_i, l_i \to p'_i, l'_i$ to the continuum. The energy conservation requires that $\varepsilon_d = \varepsilon_i$:

$$\varepsilon_d = \frac{1}{2n_d'^2} - \frac{1}{2n_d^2};$$

$$\varepsilon_i = \frac{1}{2n_d^2} + \frac{p'^2}{2m}.$$

A simple asymptotic expression of the autoionization width $\tilde{\Gamma}$ [1] for the above process can be expressed via a semi-classical expression [2]:

$$\tilde{\Gamma} = \frac{1}{n_d^3 n_i^3 R^6} \frac{3}{4\pi^3} \left(\frac{2^{2/3}\Gamma(2/3)}{3^{1/3}} \right)^4 \frac{3}{17} \left(\frac{1}{2(\tilde{n}_d)^2} - \frac{1}{2n_d^2} \right)^{-17/3}.$$

Here, $\tilde{n}_d$ is the principal quantum number of the lower level nearest to the virtual level, the effective quantum number of which, n_d^*, meets the requirement $n_d^{*-2} = n_d^{-2} + n_i^{-2}$. Our results reveal an interesting counterintuitive phenomenon: an essential increase of the ionization efficiency is observed as the principal quantum number n_d of the Rydberg atom decreases (i.e., increase ionization with decreasing atom size) - see Fig. 1.

References

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Precision laser spectroscopy of positronium atoms

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We aim to improve the current accuracy in the measurement of the energy interval of positronium (Ps) from its ground state (1S) to the first excited state (2S) by a factor of 5. This will provide a very stringent test of the theory describing atomic systems called bound states quantum electrodynamics (QED). Very recently a serious discrepancy of 5 sigma in the charge radius of the proton extracted from the muonic-hydrogen experiment at PSI compared to other experiments was found and has not yet been explained. This increases the importance of studying hydrogen-like and especially non-baryonic (with no quarks, e.g no protons) systems like positronium or muonium where finite-size effects due to the nucleus are absent. The proposed measurement will also result in the best determination of the positron-electron mass ratio that should be exactly one in order for the CPT symmetry to be conserved. This symmetry is a pillar of quantum field theory which is the base of our current understanding of particles and their interactions.

If the accuracy of the measurement could be further increased by a factor 5, this would provide a model independent test of the effect of gravity on anti-matter. The gravitational redshift predicted by general relativity was one of the great implications of Einstein's theory that was demonstrated experimentally. The pace of two identical clocks placed at different gravitational potentials is different. If gravity would act differently on antimatter, a shift between Ps and a reference clock made of matter (e.g. a cesium clock) should be observed in the different gravitational potential created by the large variation of 5 millions km of the earth's orbit around the sun during the year.

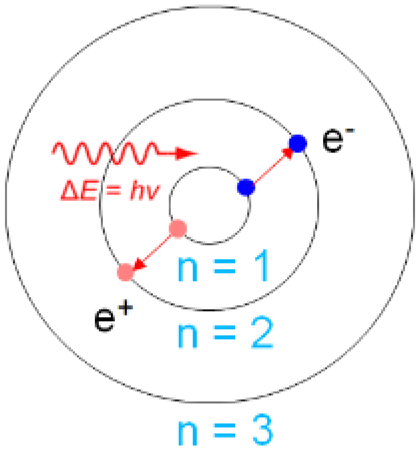

Fig. 1. Illustration of two-photon spectroscopy of positronium.

Global Network for Research in Negative Ions- Research and Project Development in 2013

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I'll present the collaboration between groups working with negative ions in Latvia, Sweden, Germany, USA, and Mexico. Historically this network started to expand from Gothenburg University Negative Ion Laboratory (GUNILA) [1] and now two large scale facilities: Berkeley National Laboratory Synchrotron Ring in USA and DESIREE (Double ElectroStatic Ion Ring ExpEriment) in Stockholm are part of it. As well groups at Universities of Freiburg, University of Mains, and University of Mexico are participants. In 2013 we participated in this network in three directions: 1) Building the Gothenburg Riga Ion Beam Apparatus (GRIBA), 2) Participation in tests of PEARLS, see for the method [3], 3) performing experiments in Stockholm University and Freiburg University.

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Towards building an effective cluster linking photonics and quantum sciences technologies and production in Latvia on the basis of the FOTONIKA-LV Project

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The competitiveness of the Latvian economy and its research excellence is dependent on its ability to form effective clusters in areas of smart specialization. To define a cluster we must go back to the original work of Michael Porter:

> *Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related sectors and related institutions (eg, universities, R&D institutions, trade associations etc.) in fields that compete but also cooperate.*

The work of the FOTONIKA-LV project can be seen as an effort to build an effective cluster for photonics and quantum sciences and technologies for Latvia and the Baltics linking RD&I with production and global supply chains. In the process of developing this cluster all related R&D institutes have been identified with their research capabilities in terms of research manpower, equipment and facilities, and external links. Additionally a data base of companies in the photonics business have been identified along with their production, sales and staffing. Companies have been invited to demonstrate their products and technologies at colloquia and conferences with scientists. FOTONIKA-LV has joined its efforts with the existing Baltic Photonics Cluster formed in 2011 in Tallinn, Estonia (see - http://bpc.edicypages.com/) and members of the BPC were introduced to the extent of photonics and quantum sciences research in the Baltics at the annual conference of BPC at the Riga Photonics Center on December 16, 2013. One of the challenges towards forming an effective photonics cluster in Latvia has been inadequate government policy and the failure of government ministries to recognize the importance of photonics to the Latvian and Baltic economies. This required a special effort to educate the ministries and agencies involved. Future plans towards building an effective photonics cluster in Latvia and the Baltics anticipate reaching out to all industrial concerns in Latvia and the Baltics involved with photonics and to build relationships with business incubators and business accelerators in the region to stimulate increased innovation, new product development as well as links with broader European photonics platforms and

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Charged Dust Odysseys

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Charged Dust:
1. Intrinsic property of matter that occurs in two forms: positive or negative, dependent on the deficiency or surplus of electrons carried by fine particles of matter
2. Obligated Trash
3. Loaded Confusion
4. Excited Lint

Odyssey:
1. An extended adventurous voyage or trip.
2. An intellectual quest

The charging of cosmic dust as a topic of study provides non-nutritive details of the important charge parameter in the electrodynamics force, which plays a dominant role over the gravitational force for the Universe's tiny cosmic dust particles. Cosmic dust particles are rarely electrically neutral because they are immersed in space plasmas, collecting ions, electrons, residual high-energy particles, and receiving ultraviolet radiation from nearby stars. The tiny particles electrically and dynamically respond to their environment with surface charge potentials which closely follow the surrounding plasma and magnetic field conditions. At the same time that the particle charges up, it is responding to its environment dynamically via the Lorentz electromagnetic force. Therefore, small cosmic dust particles are ideal tracers of their astrophysical environments.

A variety of charged cosmic dust populations exist in our solar system. The variable charging of the small dust particles leads to the particles' non-nutritive trajectories. Of the dust populations within the magnetospheres of the planets, one of the most dramatic examples of the charging of cosmic dust is the Jovian dust streams: high-speed (at least 200 km/sec) collimated streams of submicron-size particles travelling in the same direction from a source (Io) in the Jovian system. Saturn, with a different source and a different plasma environment joins Jupiter with a similar magnetospheric dust stream phenomena. The Saturnian system not only has its Saturnian dust streams, it has the large E-ring as well, into which feeds Enceladus' dusty plumes. The E-ring dust can further splatter onto the mid-sized icy moons revealing albedo patterns of their source. Of the populations of charged dust outside of planetary magnetospheres, are those on the surfaces of airless bodies such as the Moon and asteroids. What makes an asteroid an especially attractive dust laboratory is its fine regolith embedded in the interplanetary plasma and illuminated by solar photons. Electrostatic forces have been specifically invoked as one means by which small grains can be transported across an airless body’s surface in what is known as electrostatic levitation.

Search for Experimental Evidence of Non-statistical fragmentation of Large Molecules

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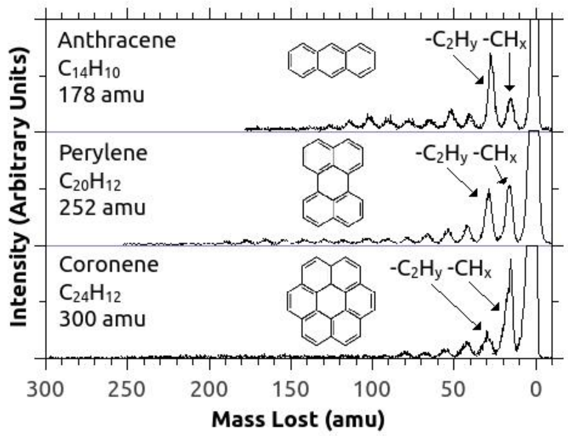
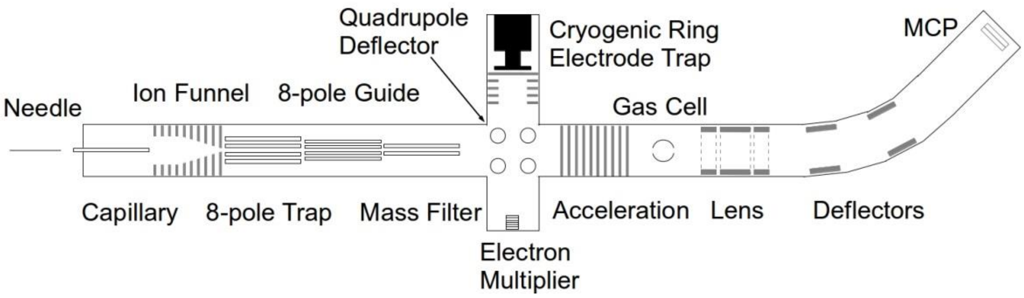
Polycyclic Aromatic Hydrocarbons (PAHs) are an important component of interstellar dust and gas and are probably responsible for the ubiquitous infrared emission bands present in the spectra of many galactic and extragalactic sources [1]. The processes by which PAHs and other large molecules (e.g. fullerenes) are formed and destroyed in the interstellar medium are not yet understood.



We will present an experimental study of collisions between small (14 to 24 carbon atoms) PAH (or nitrogen substituted PAHN) ions and rare gases. The results differ qualitatively from previous work, particularly in the CH_x-loss channel, which is much more prominent than in typical collision induced dissociation (CID) experiments and here even becomes dominant for the larger PAHs.

In thermally driven processes such as photo dissociation, emission of H atoms and strongly bound C_2H_2 units typically the lowest energy decay pathways. For the present collisions, fragmentation is frequently initiated by prompt, non-statistical knockout of single carbon atoms, after which the excited fragment ion may decay further.

The electrospray ion source [2] (2002 Nobel Prize in Chemistry) used in this work, or a copy of it, may also be mounted at the DESIREE double electrostatic ion storage ring [3]. This will enable collisions with a variety of ions at low (10 K) temperatures and with center-of-mass energies in the meV range.



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Universal vacuum sputtering device to satisfy diversity of sophisticated experimental needs and industrial demands

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The aims of activities at technical laboratory basement at LUASI are

1) to create a high-tech dust-free cleanroom subsystem on the basement floor of LUASI (ventilation, filtration, heat and humidity control etc.) to exploit the VU2 vacuum multilayer thin film coating machine minimizing defects of the products nanofabricated on the universal stand

2) to provide an advanced upgrade of the machine, or, in details:

a) to retrofit the cabling system off the relay driver logics toward Arduino based driver logics, similar to what we did in December 2013 for sputtering apparatus at the Optics Division of the Crimea Observatory

b) to buy, accommodate, fit and mount a new oil-less maglev vacuum pumping system instead of the old defected diffusion system

c) to buy up and to implement a quartz phase-shift based thickness control system for real time control of sputtered layers

d) to implement RF ICP de-electrisation coil for glass to glass kind of layers, for dielectric interference filters

e) to implement water recirculation cooling system (for water economy)

3) to provide minor repairs to the small thermal deposition machine VUP5 to accommodate it for contact patch metallization, for CVD deposition and for student training needs

4) to mount a large astronomical mirror aluminium coating vacuum apparatus and interferometer stand for mirror-geometry control.

5) to install mirror grinding and polishing machines in the side-rooms

6) to relocate the ASI frequency comb standard apparatus from 2-nd floor and connect it to all interested user-labs

7) to build a Czohralsky crystal-growth vacuum oven for semiconductor materials to substituting the ones we are renting at the LUCFI

8) to build a zone-rectification system for high-purity semiconductor crystals required by industry

9) to build an innovative portable ion implantation system for semiconductor crystals;

10) to relocate our portable Gothenborg-Riga negative ion exploration apparatus GRIBAM presently operated at Chalmers (SE), and use it for experiments and student training in atomic and molecular spectroscopy.

By the planned activities the presently unused basement floor will be transformed into premises for high-tech product development and innovation to provide crucial help with technically complex parts for use in our experiments and/or for needs of hi-tech photonics R&D SMEs.

All the mentioned work is in on-the-fly stage and expected to be finished graduate within the Project FOTONIKA-LV.

Laser manipulation of quantum states

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Interaction of strong coherent laser fields with quantum states of atoms and molecules is a versatile tool allowing the alteration of atomic and molecular quantum states during their interaction with the light field. The simplest example is the well-know Autler-Townes effect in a three-level system: two levels are coupled by a strong coherent radiation field creating the adiabatic (or dressed) states, whereas a weak probe field coupled to a third level will produce the typical doublet in the probe excitation spectrum [1]. The present report reviews our results on possible applications of the Autler-Townes effect to population switching and manipulation of transitions among hyperfine levels.

The first part of the talk will consider a three-level system *g-e-f* coupled by two laser fields which produces interference patterns in the probe excitation spectrum. A strong laser field *P* coupled between the levels *g* and *e* prepares the system in a given adiabatic state, from where the population is transferred to a high lying state *f* using a second, weaker laser field. The excitation spectrum of level *f* will yield interference fringes resulting from two excitation pathways to level *f* due to Landau-Zener crossings of adiabatic states. Population of level *f* can be switched by changing the detuning of the weaker field between the interference maxima and minima.

The second part of the talk will discuss the formation of dark states upon interaction of hyperfine level systems with strong laser fields [2]. We consider here degenerate three-level systems with hyperfine structure. In this type of experiments, the strong laser field would normally couple the upper two states *e* and *f* producing a number of adiabatic states depending on the hyperfine structure of each level, which are then probed by a weak laser field from the ground state *g*. We show that unequal number of hyperfine sublevels in states *e* and *f* will lead to the formation of dark states, whereas in the case of equal hyperfine structure of *e* and *f* dark states are not formed. Experimental implications of this phenomenon will also be discussed.

We acknowledge the support by the EU FP7 REGPOT project FOTONIKA-LV, the EU FP7 IRSES Project COLIMA, US Office of Naval Research Grant No. N00014-12-1-0514, and the trilateral project supported by the Latvian, Lithuanian and Taiwanese research councils.

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Crystal Growth Conference in Gdansk

Ojārs Balcers

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I have participated in 15th International Summer School on Crystal Growth (ISSCG – 15) was held on 4-10 August 2013 in Gdańsk, Poland. The summer school in Gdansk preceedes a related Conference Event in Warsaw. The summer school was a great opportunity to learn the main research topics in the crystal growth field. New useful contacts were established.

The summer school was be held at Main Building of the Gdansk University of Technology and hosted by the Faculty of Applied Physics and Mathematics Gdansk University of Technology.
It was chaired by:

- Ewa Talik, University of Silesia, Katowice, Poland
- Wojciech Sadowski, Gdansk University of Technology, Gdansk, Poland
- Elke Meissner, Fraunhofer Institute of Integrated Systems and Device Technology IISB, Erlangen, Germany
- Peter Wellmann, University of Erlangen-Nürnberg, Erlangen, Germany

One can say that this is a major event in the crystal growth field and certainly the closest to Latvia in a longer period of time. Next Crystal growth conference in this series will be held in Japan.

Main topics covered were

- *From Jan Czochralski to high-pressure nitride growth – the development and topics of crystal growth in Poland*;
- *Thermodynamics of crystal growth*;
- *Nucleation and Growth Kinetics*;
- *Continuum transport of heat, mass, and momentum in crystal growth processes: Fundamentals and computational modeling*;
- *In-situ observation of crystal growth by advanced optical methods*;
- *Growth from melt*;
- *Vapor (PVT) (with focus on SiC and AlN)*;*Solution growth of intermetallic compounds*;
- *Crystal defects*;
- *Epitaxial Growth - from Basic Concepts to Reality*;
- *Metalorganic Vapour Phase Epitaxy of GaN on Si: from Principles to Devices*;
- *Pivotal Role of Molecular Beam Epitaxy (MBE) in the Development of Nanoscience and Nanotechnology*;
- *Fundamentals of crystallography*;
- *Characterization (electrical, optical, structural, chemical)*;
- *Biomineral and Biomimetic Crystallization*;
- *Self organizing materials*;
- *Nanocrystals*;
- *Graphene - Chemistry and Physics of Epitaxial Growth*.
- *New trends and challenges in crystal growth in scientific and commercial aspects*.

It was decided not to present. There were many research topics and experimental and calculation methods that are of interest for further co-operation. For example, an interesting poster report on modelling of massive Si growth was presented by a German Scholar who graduated the University of Latvia. Then, the method of crystal growth in evacuated ampoules is being performed in several locations, Gdansk being the nearest.

Main learnings are that crystal growth science becomes applied and develops towards miniaturization, as well uses fair amount of modelling. Researchers work with advanced experimental set-up, so the fastest way to results is to do research where it is supported.

Foresight studies for photonic industry in Latvia - project FOTONIKA-LV foresight workshops

Ms.oec. S.Smalina

Association FOTONIKA-LV, University of Latvia

One of the goals set in the project FOTONIKA LV is Contribution to policy development by conducting 3 strategy planning workshops including technology foresight exercises for national and regional scale developments in photonics fields resulting roadmaps policy advice documents for decision makers, governments and National Photonics Strategy Group.

The 1st regional workshop "Photonics, Quantum Sciences and technologies in Baltic countries, the 1st regional workshop on strategy planning and technology foresight" was organized in October 9-11, 2013 with Dr. Kerstin Cuhls support from Fraunhofer Institute for Systems and Innovation Research science.

Goals of the seminar were:

1) To introduce FOTONIKA LV community, photonic industry representatives and governmental institutions representatives with essence of the foresight and its potential in future planning;
2) To define existing situation main problems for Photonic industry;
3) Make road mapping exercise for one of photonic sub-sectors.

Planned outcomes of the seminar were:

1) Photonic community introduced with Foresight mains principles;
2) Listed photonic sector problems and challenges;
3) Listed sectors where photonics is part of the industry;
4) Define sector with the largest Photonic usability and created science and technology roadmap for Photonic opportunities.

During foresight seminar through brainstorm session following industries were identified as important for photonic sector development: health sector, foresting, Agriculture, Food processing, Fiber optics, Wireless optics, Space, application for chemical industry.

During workshop a Roadmap for health sector was designed where Science and research, Technology, Applications and Actors today were identified in 30 years timeline.

Following stages are crucial for future foresight sessions organization.

1) Planning phase:
   - Identify context and problems;
   - Purpose and desired outcomes;
   - Situation analysis and stakeholder analysis;
   - Elaborate plan for achieving purpose and outcomes, develop a format of the seminar (different types of social communication formats can be used to contact stakeholders);
   - Ensure public participation, it is needed common understanding of challenge and problem for with public participation in desirable;
   - Ensure information circulation and plan for public engagement.
2) Participation phase could be divided in to more stages and variety of participation methods can be used.
3) Compilation of results, spreading through participants.

Fundamental parameters of carbon stars obtained from low resolution spectra

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The scientific interests of the Latvian astronomers in the field of stellar astronomy from the very beginning were directed mainly to carbon stars. Therefore, the majority of plates, both direct and spectral, obtained with the Baldone Schmidt telescope, cover the zone along the galactic equator, where the galactic carbon stars are concentrated. The spectral observations have been obtained using 80 cm diameter objective 4° prism, that provide the reciprocal dispersion of 600 Å/mm at the hydrogen line Hγ or spectral resolution ~500 at Hα.

A search for new faint carbon (C) stars in the Polar region $\delta > 60^{o}$ have been accomplished by obtaining objective prism spectra in the near infrared 5500 - 9000 Å on images of CCD camera ST-10XME. The positions of stars having colour indices J - K>1.3 magnitude in Two Micron All Sky Infrared Survey (2MASS) were selected to pick out suspicious carbon stars.

Our survey is limited in brightness by J<10 magnitude. 15 new carbon stars were found. Such characteristics as Teff, distance from the Sun,
absolute (M_k) and bolometric (M_{bol}) magnitudes of newly carbon stars were obtained.

The correlative relation between T_{eff} from [2] and spectral gradient [7570 - 6850] from Baldone Schmidt spectra was confirmed on the basis of 191 C stars (see Fig.1.).

The interstellar extinction to determine the distances to C stars by two methods: by [1] tridimensional model of Galactic interstellar extinction and by Schlegel (1998) infrared dust emission maps were estimated. The dependence of absolute magnitude on J-K was taken into account using the correlation obtained by [3] in the LMC. The distances obtained by two methods differ significantly for objects with dust envelopes, and also for carbon stars located very close to the Galactic plane.

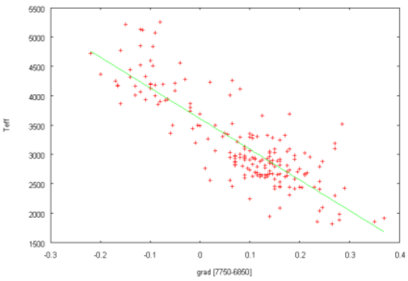

Fig.1. Correlation of T_{eff} of C stars with spectrophotometric gradient.

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Gothenburg Riga Ion Beam Apparatus GRIBAM- Status and Perspectives

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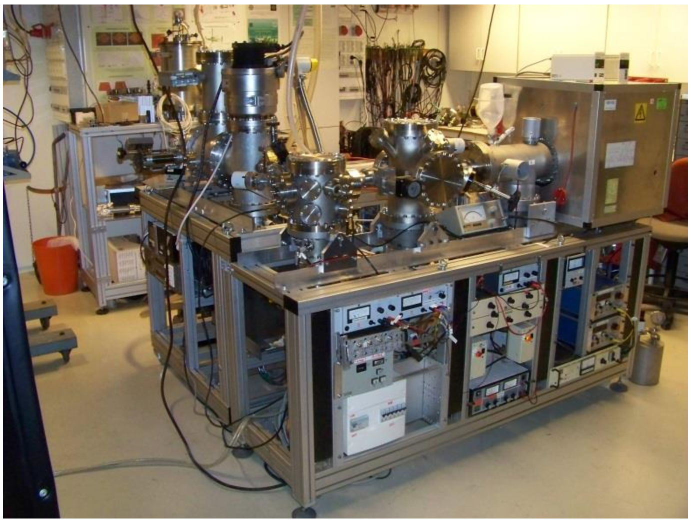
The construction of GRIBA (Gothenburg Riga Ion Beam Apparatus) is a collaboration between University of Latvia and University of Gothenburg. It was started in frame work of FP7 FOTONIKA-LV in the beginning of year 2012. Equipment available at University of Gothenburg has been used to construct an ion beam apparatus. Many visits from Riga to Gothenburg have been performed during the two years of the project. The main work of the construction has been performed by the Riga group. Recently the first ion beam of Cl anion was transported through the apparatus.

Our main idea is to build an apparatus from few easy transportable modules: 1) ion source with mass selector, 2) experimental chamber with electron spectrometer, and 3) Laser system. The apparatus will be used for studies of the photodetachment process of atomic and molecular negative ions.



The apparatus will, after commissioning experiments, be move to Ion lab in Atomic Spectroscopy Institute (ASI), at University of Latvia in Riga. The equipment will be used by Latvian students and researchers in collaboration with guest researchers. After further modifications it will be possible transport GRIBA to other research facilities, such as synchrotron or high power laser facilities, for more advanced experiments.

"Properties of Atoms in the Negative Ion and Femtosecond Laser Radiation Interaction" the Collaboration between University of Latvia and Freiburg University financed via Baltic-German University Liaison Office

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[2]*Department of Molecular Physics and Optics, Freiburg University, Freiburg, Germany.*

This was first collaboration between our two institutes and main target for Latvian team was to participate in some experiment with negative ions and have hands on femtosecond laser used in Freiburg. Recently very interesting experiment on carbon atoms was performed by using this laser, and by using the carbon anion beam for formation of carbon atom beam [1]. During our visit the experiment for measurement of beta coefficient in photo detachment of C^- was set up.

Important part for this project was to establish closer contacts between our two institutes, and search for potential future collaboration.

This project of the Baltic-German University Liaison Office is supported by the German Academic Exchange Service (DAAD) with funds from the Foreign Office of the Federal Republic Germany.

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Overview of scientific benefits of FP7 FOTONIKA-LV project's secondment visits to research capacity in Biophotonics laboratory of the Institute.

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Within the Fotonika-LV secondment program leading researcher from Institute of Atomic Physics and Spectroscopy PhD Aleksejs Lihacovs was participated in scientific training course organized by Vilnius University Laser Research Center. During the visit practical and theoretical aspects of time resolved fluorescence spectroscopy application in bio-photonics has been studied. Particular interest of the visit was aimed to investigation of skin fluorophores lifetimes during long-term continuous laser excitation, as well as data collection and signal processing. During the visit were investigated the impact of fiber optic probe on system response function and quality of collected fluorescence lifetime signals.

Practical and theoretical skills derived during the Fotonika-LV secondment program gave a significant contribution in development of a new research direction in fluorescence lifetime spectroscopy in Biophotonics Laboratory.

The visit was held in May 2013 in Vilnius University, Laser Research Center, Vilnius, Lithuania.

Special Thanks to prof. Ričardas Rotomskis for organizing and warm welcoming and PhD Saulius Bagdonas for technical assistance and scientific training.

The secondment was funded by financial support of "Fotonika-LV – FP7-REGPOT-CT-2011-285912" project.

Skin fluorescence diagnostics with a femtosecond optical frequency comb

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Optical spectroscopy is powerful tool to probe biological tissue and has advantages over other methods by being fast and without damaging the sample. Due to skin being highly inhomogeneous and consisting of particles and structures with different properties as well as sizes, the light in skin can be either absorbed or scattered.

The fluorescence of skin is excited mainly with the ultraviolet (UV) or blue light and important issue is the penetration depth of the light because it limits the depth from which information can be obtained in a non-invasive way.

The fluorescence signals of the skin are each produced in distinct spectral regions but the spectrums overlap and are difficult to separate. Still the fluorescence of pathological changes can be predicted and detected. Even more information can be obtained by using very short (fs, ps) laser impulses to excite the sample and observe the kinetic of the fluorescence. We use Erbium-fiber-based optical frequency comb synthesizer that covers a broad optical spectrum 530...1000 nm emitting 150 fs pulses with 4ns repetition period. The broad emission spectrum of the frequency comb laser makes it a more robust tool compared to a pico-second diode laser. Fluorescence decay curve allows to measure skin scattering and absorption coefficients for particular color range.

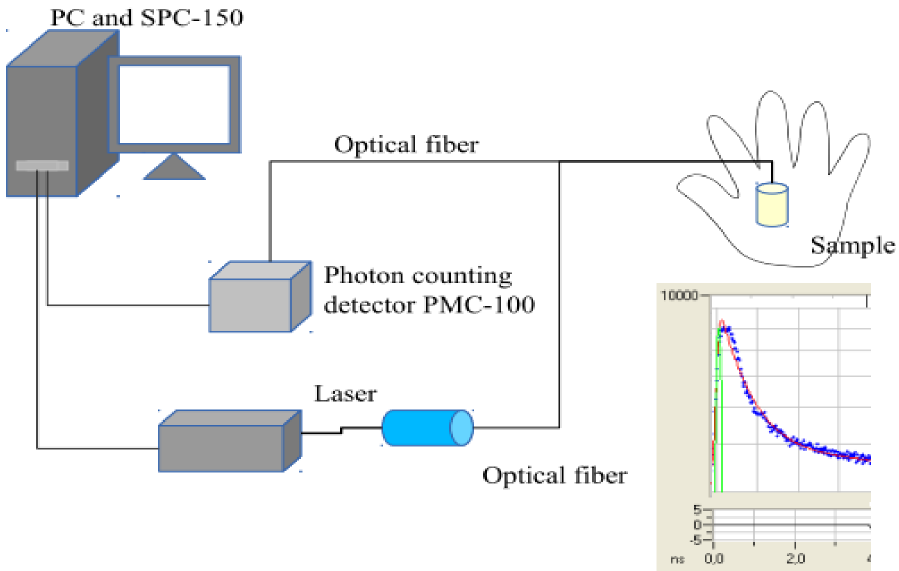

Fig. 1. Experimental scheme.

Improvement of Latvian geoid model

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The high precision geoid model is essential for precise normal height determination when the GNSS positioning methods are used. In Latvia gravimetric geoid model LV'98 is broadly used by surveyors and scientists. The computation of this model was performed using GRAVSOFT software using gravimetric measurements, digitized gravimetric measurement data available on USSR era maps and satellite altimetry data over Baltic Sea, the estimated accuracy of LV'98 geoid model is 6-8cm [3]. But 15 years have passed since the creation of LV'98 and the precision of Latvian geoid model is no longer compatible with that of GNSS measurements and volumes of use.

In order to improve the accuracy of Latvian geoid model, the evaluation of several methods and test computations have been made.

KTH method was developed at the Royal Institute of Technology (KTH) in Stockholm. This method utilizes the least-squares modification of the Stokes integral for the biased, unbiased, and optimum stochastic solutions. The modified Bruns-Stokes integral combines the regional terrestrial gravity data with a global geopotential model (GGM) (R. Kiamehr, 2006). Experimental gravimetric Latvian geoid model was computed using digitized gravimetric measurement data from USSR era maps but more precise model for Riga region was achieved using recent gravimetric measurement data.

DFHRS (Digital Finite-Element Height Reference Surface) method has been developed at the Karlsruhe University of Applied Sciences, Faculty of Geomatics [2]. In the DFHRS concept the area is divided into smaller finite elements – meshes. The height reference surface N in each mesh is calculated by a polynomial in term of (x,y) coordinates. Each group of meshes forms a patch, which is related to a set of individual parameters, which are introduced by the datum parameterizations. As an input data the European Gravimetric Geoid Model 1997 (EGG97) and 102 GNSS/levelling points were used.

Astrogeodetic method is known since mid-20th century, however with little recognition, since the acquisition and processing of high quality data was a slow and laborious process. During the recent decades and thanks to the emergence of charge-coupled device (CDD) imaging technologies, this method has become increasingly popular. It provides a faster result with a smaller number of measurements than in the case of gravimetric methods using CCD imaging technologies and recently complied massive areosptatial star catalogues. In order to apply and expand the astrogeodetic method in Latvia, the prototype of mobile digital zenith telescope for determination of vertical deflections is developed at University of Latvia, Institute of Geodesy and Geoinformation [1].

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FP7 ERA-NET+ "Biophotonics": project call and success of the Biophotonics Laboratory

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European Commission launched the two-stage *ERA-NET plus* call on Biophotonics in October 2012, with full-proposal deadline in April 2013 (http://www.biophotonicsplus.eu/). BiophotonicsPlus is a joint initiative of seven participating countries (Germany, UK, Israel, Latvia) and three regions (Tuscany, Catalonia, Flanders) to stimulate and fund R&D projects which will translate the existing biophotonic technology and methods into appliances and put them into clinical, medical or industrial practice. Up to 15 million EUR combined EC and member government funds are allocated to innovative projects which involve eligible participants/beneficiaries from at least two of the participating countries and regions.

Biophotonics Laboratory of IAPS has co-ordinated one project proposal and participated as a partner in four other proposals. The co-ordinated project, unfortunately, was not evaluated due to ineligibility of the Catalan partners. However, two of the partner projects were supported and one evaluated below the "success line" but still kept on the waiting list. Start of the supported projects is expected in year 2014.

One of the supported projects (BI-TRE) intends to realize an efficient, reliable and cost-effective laser technology for minimally invasive repair of vascular tissues and wounds of the oral cavity. Customized laser procedures that will be adapted from already established laser techniques including corneal and vascular laser welding will be set-up. The minimally invasive repair will rest on the photothermal activation, i.e. mediated by laser, of endogenous or biocompatible absorbing materials that are already present or are applied at the site to be repaired. The laser platforms will integrate sensors and real-time controllers for the photothermal process. These will include a thermal imaging system for real time recording and analysis of the temperature elevation during laser-activated vascular repair procedures, a temperature sensor for temperature-controlled tissue coagulation and an optical backscatter sensor for detection of morphological changes of oral cavity tissue. The proposed biophotonic technologies for Tissue Repair (BI-TRE) based on laser action will be validated by end-users in a pre-clinical environment.

The other supported project (O-PPGM) proposes to measure blood pulsations of internal organs by combining an ultra thin endoscope and an optical device for non contact measurement of movements; the latter has already been demonstrated before e.g. for sensing the beatings of skin blood pulsations. The idea here is to construct an integrated device in which the endoscope will approach the internal organ in a minimally invasive manner while the optical device for sensing the pulsation will be positioned outside the body of the patients and after proper calibration will estimate the pulsation parameters.

Experimental Observation Of The Formation Of Multiple Dressed States In Sodium Hyperfine Level Systems

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We present the latest results of experimental study of the formation of multiple dressed states in sodium hyperfine level systems upon coupling by a strong laser field. The study was performed in a geometrically cooled supersonic beam of sodium atoms. A three-level ladder excitation scheme was employed, with a weak probe laser beam used in the first excitation step and a strong coupling laser beam in the second step (Fig.1.). The two laser beams are aligned perpendicular to the supersonic beam to minimize Doppler broadening. Both laser beams are linearly polarized with polarization directions parallel to the supersonic beam, which defines the quantization axis. Dependence of florescence intensity on detunings Δ_S and Δ_P is observed.

Depending on the hyperfine levels involved, the coupling by a sufficiently strong laser field can lead to formation of dark states. Dependence of the dark state formation on the configuration of strongly coupled HF levels, predicted by our theoretical model, has dramatic effects on addressability of the dressed-state components by a weaker probe field. We have obtained an explicit representation for bright and dark states for a number of excitation ladder schemes in sodium atoms [1]. By examining the specific case of the selection rule $\Delta F \equiv 0$ in two-photon transitions that result from strong interference of the atomic states in the middle step of the ladder, we suggest a scheme for selective addressing of unresolved or partly resolved HF components.

We acknowledge the support of EU FP7 Centre of Excellence project ”FOTONIKA-LV–FP7-REGPOT-CT-2011-285912”, EU FP7 IRSES project COLIMA and ONR Global NICOP Grant Electromagnetic Field Mapping and Population Switching by Coherent Manipulation of Laser-Dressed Rydberg States.

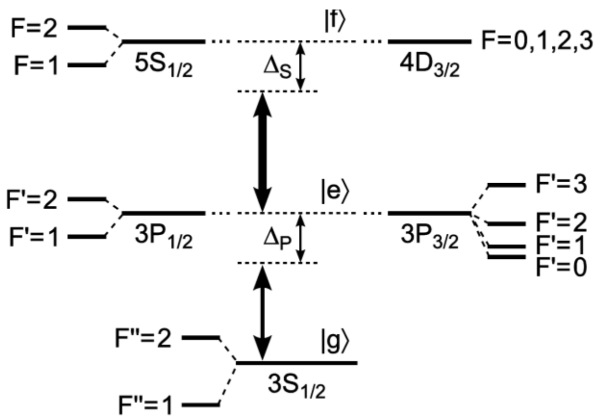

Fig.1. Ladder excitation scheme in sodium.

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The first year outcomes of the FOTONIKA-LV project – “BIOSENSORS-AGRICULT”

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Within secondment visits during 2012-2013 the project participants made secondment visits to Linkoping, Sweden; Montpellier, France; Riga, Latvia; Odessa, Ukraine and Minsk, Belarus. The following scientific results were obtained:

In Linkoping:

ZnO nanostructures with different morphology and stoichiometry, deposited by MOCVD.

-Investigated structural and optical properties of the prepared samples.

-Functionalization and testing of samples for biosensor applications

-Biosensor tests for detection of Salmonella, leucosis and glucose probes.

In Riga and Odessa:

-TiO_2 nanostructures deposited from nanopowder.

-Characterization of structural and optical properties

-Functionalization and testing of samples for biosensor applications.

-Biosensor tests for detection of salmonella and leucosis probes

In Minsk and Riga^

-Novel method of immobilization of bioactive compounds was developed.

In Montpellier, Riga and Odessa:

-ZnO, ZnO/Al, Al_2O_3/ZnO, Au/ZnO and ZnO/Au nanostructures have been deposited by Atomic Layer Deposition technique

-Characterized structural and optical properties of the prepared samples

-Functionalization and testing of samples for biosensor applications.

-Biosensor tests for detection of Salmonella, leucosis and glucose probes

On the basis of the scientific results 6 publications were published, 6 conferences were attended, 4 international project applications were submitted.

The foresight activities at the FOTONIKA-LV and support from the project - “FP7-PEOPLE-IRSES-GA-2011-294959 - International Foresight Academy” (2012-2015)

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The mission of the FP7-REGPOT-2011-1 project FOTONIKA-LV is to drive the development of an effective cluster in Latvia that promotes photonics and quantum technology R&D excellence linked to industry producing innovative high value added products as a smart specialization strategy for Latvia and its neighbouring Baltic countries Estonia and Lithuania. Choosing research themes and technologies to develop that stimulate smart, long term growth is dependent on insightful technology foresight, which is why FOTONIKA-LV is promoting the development of foresight and foresight related skills among researchers, business managers and government officials in Latvia and in neighbouring Estonia and Lithuania. The FP7 project FP7-PEOPLE-IRSES-GA-2011-294959 - “International Foresight Academy” is consortium project led by Dr Susanne. Giesecke of the Austrian Institute of Technology. The following research institutions are represented:

- International Institute for Applied Systems Analysis , Austria;
- Zurich University of Applied Sciences, Switzerland;
- The Executive Agency for Higher Education, Research, Development and Innovation Funding, Romania;
- Finland Future Research centrum at Turku University;
- The Interdisciplinary Centre for Technological Analysis and Forecasting at Tel Aviv University; Israel;
- Center for Strategic Studies and Management in Science, Technology and Innovation, Brazil The Latin American School of Social Sciences, Argentine;
- Foresight Canada;
- Higher School of Economics, Russia
- Science & Technology Policy Institute, South Korea

The proposed International Foresight Academy is the first organization to bind together Foresight activities around the globe and from contrasting cultural and political contexts. Foresight is used differently in various regions of the world. During the past 30 years, foresight has become an unconventional means of political priority setting and strategic decision making that affect a wide set of societal stakeholders – in European Member States as well as at European policy level. To consider a broad spectrum of new knowledge and make use of very different perspectives in order to find the most feasible and socially sound option, today, policy makers turn more and more to foresight (FS) as an instrument for long-term planning.

The added value of foresight is seen in the shared goals and visions among a group of participating actors from different sectors, the development of networks, and the combination of relevant information on current trends and future developments with actor-based information and attitudes. Many foresight practitioners value the possibility granted by foresight exercises to bring topics on the political agenda that need to be discussed not behind closed doors but with broad public involvement.

The Association FOTONIKA—LV has been invited to join the foresight consortium the first half of 2014. The principles and knowledge that we expect to gain through secondements and other forms of participation in the project will help us to drive the FOTONIKA-LV mission. Dr. Ojars Balcers and Ms. Sandra Smalina already benefited from participation in the Foresight Academy summer school organized in Salzburg in summer 2013.

The first year outcomes of the FOTONIKA-LV project - " Nocturnal Atmosphere", FP7-PEOPLE-2011-IRSES, G.a.294949 (01.02.2013-31.01. 2017)

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The association FOTONIKA-LV at the University of Latvia is a partner coordinator of the project **" Nocturnal Atmosphere", FP7-PEOPLE-2011-IRSES.** There are 4 more partners in the project consortium:

University	***Deaprtment***
University of Bremen	*Institute of Environmental Physics (IUP) and Institute of Remote Sensing (IFE)*
Max Plank Institute for Chemistry (MPI Mainz)	*Atmospheric Chemistry Department and Satellite Remote Sensing Group*
National Academy of Sciences of Ukraine	*Institute of Fundamental Problems for High Technology (IFPHT)*
Central Institute of Aviation Motors	*Scientific Research Center "Raduga"*

The project has four Work Packages:

- Technology development of active nigh-time remote sensing;
- Theoretical assumptions and model experiments of long-distance broadband spectra light beam propagation in the Earth atmosphere;
- Nocturnal chemistry and photochemistry in atmosphere;
- Measurements of reference spectra

During the first year of the project run main activities were concentrated to the WP1 and some preparatory actions for the WP2. Some delay was in place with the start of secondment visits exchange programme because members of Riga team were involved in the preparation of the next IRSES project proposal targeting to SLR and Earth Geodynamics issues.

The first exchange visits were from Riga to Kyiv, where the Coordinator of the project and the Director of Institute of Astronomy visit colleagues in Kyiv to agree on the agenda of forthcoming visits. In joint discussions and in examination of experimental capacity joint team come to the conclusion that new technology allows to measure reflected from the satellite white light beam signal on Earth station. Colleagues in Kyiv has relevant ideas on that and that will contribute significantly to the progress of the project!

The FOTONIKA-LV in the project - An international network on new strategies for processing calcium phosphates, FP7-PEOPLE-2013-IRSES, G.a.612691 (01. 12.2013-30.11. 2017)

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The association FOTONIKA-LV at the University of Latvia is a partner of **FP7-PEOPLE-2013-IRSES – Refined Step project led by Dr.Karlis Agris Gross** Biomaterials science and research laboratory at the Riga Technical University. There are another 8 partners in global consortium:

- Belfort University of Technology of BelfortMontbéliard, Department of Mechanical
- Engineering and Design, France;
- Department of Chemistry, London University College London, UK;
- Ludwig Boltzmann Institute for exp & clin traumatology, Ludwig Boltzmann Gesellschaft, Austria ;
- The Institute of Heat and Mass transfer, National Academy of Science of Belarus;
- Tomsk Polytechnic University, Russia;
- The Faculty of Chemical Engineering, Sherbrooke University, Canada;
- The Dept of Chemical Engineering and Biotechnology, National Taipei University of Technology, Taiwan
- Department of Pathology , University of Adelaide, Australia

The project just started. The task of FOTONIKA-LV team is focused on advancing the high temperature processing capabilities with radiofrequency (RF) inductively coupled plasma as a new processing tool in clean high temperature processing environment and thereby provide a new tool to complement existing processing capabilities to study the high temperature changes in a controlled parameters of physical environment and provide the basis for the design of the next-generation calcium phosphates. This high temperature environment will be an extension from presently used RF-plasma spray technology and will therefore benefit presently used thermal spray capabilities as well as designing a new torch to expand the range of high temperature processing capabilities. The complex logics of secondment visits among partners is foreseen to ensure knowledge transfer and to collect critical mass of human resources to boost research efforts in selected laboratories.

Cooperation of Association of FOTONIKA -LV and the Fraunhofer Institute for Systems and Innovation Research to Develop Technology Foresight Mentality in Latvia and in Particular for Photonics Domain

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FP7-REGPOT-2011-1 project FOTONIKA-LV is supporting efforts to learn and to study innovation aspects and technology foresight towards photonics RTD on a national scale, neighbouring Estonia and Lithuania. The strategic planning and technology foresight in photonics and top level innovations are new areas for the the FOTONIKA-LV Community. The same relates to decision makers at the university, municipal and government levels not only in Latvia, but also in neighbouring Estonia and Lithuania. 4 short personal exchange visits and several virtual communications via SKYPE were made during the first 18 months to settle the agenda and logistics of planned events in Riga.

After that thre related to the task events were raised in Riga in July 2013 and in October 2013 and December 16, 2013.:

- The 1st Baltic Countries regional workshop. Inventory of capacity: Human resources; Industry; Intelectual Capital and IPR assets, Riga July 26, 2013;
- Photonics, Quantum Sciences and technologies in Baltic countries. The 1st regional workshop on strategy planning and technology foresight, Riga October 11-13, 2013;
- The 1ST Baltic Photonics Innovation workshop. Challenges for the Photonics community in Estonia, Latvia and Lithuania, December 16, 2013.

On the event in October 11-13. National Photonics Strategy Board were declared. The experience of the usage of technology foresight methodology used by Federal Ministries to develop photonics strategy in Germany were shared by Kerstin Cuhls with the audience of the workshop.

In spring 2013 National activities started to design regional smart specialization strategy for Latvia. The Ministry initiatives were late for at least one year because deadline was at the end 2013. There were no time for serious SWOT analyses and suggestions to use resources of FP7 FOTONIKA-LV project to start some foresight activities were not taken seriously.

FOTONIKA-LV community raised bottom-up initiative to propose “Photonics, Quantum Sciences and technologies” as a domain of smart specialization in Latvia and even in Baltics. Mentioned above workshops were synergistically used to discuss the issue and to train people on strategy planning and foresight issue.

Basing on mentioned starting events the plans are developed for more substantial activities in year 2014. Longer foresight secondment visits are planned to Fraunhofer ISI (*http://www.isi.fraunhofer.de)* and 2-3 foresight exercise events will be raised in Riga for selected groups of experts including National Photonics Strategy Board.

Membership of the Association FOTONIKA-LV in the European Photonics industry Consortium

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EPIC is the European Photonics Industry Consortium[1], a membership-led not-for-profit industry association that promotes the sustainable development of organisations working in the field of photonics. Our members encompass the entire value chain from LED lighting, PV solar energy, Silicon photonics, Optical components, Lasers, Sensors, Displays, Projectors, Optic fiber, and other photonic related technologies. We foster a vibrant photonics ecosystem by maintaining a strong network and acting as a catalyst and facilitator for technological and commercial advancement. EPIC works closely with related industries, universities, and public authorities to build a more competitive photonics industrial sector, capable of both economic and technological growth in a highly competitive world-wide marketplace. EPIC is registered on the European Commission Transparency Register under identification number: 04635146585-36.

Association FOTONIKA-LV became a member of EPIC late in 2013, but before the Director General of EPIC Carloss Lee visited Riga in July 25-26, 2013 and participated and contributed to two workshops raised by FOTONIKA-LV:

- *FOTONIKA-LV & Z-LIGHT. The 1st interactive workshop for cooperation PHOTONICS AND QUANTUM TECHNOLOGIES, LIVANI, LATVIAM 25.082013;*
- The 1st Baltic Countries regional workshop. Inventory of capacity: Human resources; Industry; Intellectual Capital and IPR assets, Riga July 26, 2013.

More than 100 members of EPIC is part of impressive EU photonics industry sector (€ 62 billion sector, employing directly more than 300 000 skilled workers. Photonics is positioned within the European Commission as the largest Key Enabling technology in Europe.

Membership of FOTONIKA-LV in EPIC means – visibility and representation of photonics community of Latvia in EU Photonics landscape access to EPIC's market studies, technology reports, newsletters and flash alerts at no charge and to get support for R&D activities oposals[2].

FOTONIKA-LV was represented in EPIC 10 years anniversary meeting and complementary events by it's scientific secretary Dr. Arnolds Ubelis and Pof. Janis Spīgulis

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[1] www.epic-assoc.com, *http://www.vtt.fi/files/sites/eemeli13/12_Karioja_EPIC.pdf*

[2] *"EPIC membership is an investment. In 2010 EPIC-led programmes returned more than 2.2 million EUR in direct benefits to its members. This return is 11.4 times the amount of all the membership dues paid in that period."* Carlos Lee, Director General, EPIC

Photonics, quantum sciences and technologies regional smart specialization in Latvia, Lithuania, Estonia

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The Association FOTONIKA-LV has an objective to promote and to contribute to structural changes in sciences and technologies landscape of in Latvia. Besides intensifying research activities this requires also integration leading towards mobilization of research community that means mutual understanding of capacities, strengths and weaknesses in particular in the domain of Photonics, Quantum Sciences and Technologies. During the Year 2013 the authors contributed to organization and participated in 5 events targeted to above mentioned tasks[3]:

There is growing in size and recognized worldwide community of researchers in the domain in Baltic countries in public research institutes. In Latvia they participate in the implementation in 15 FP7 projects where funding to Latvian partners is *€7,3M.*

The project 9 – 4,49	Money for LV
1. FP7-REGPOT-2011-1, FOTONIKA-LV, Nr. 285912	*€ 3.,753 M*
2. II LASERLAB-EUROPE, Contr.Nr. 228334, INFRA 2008-1.1.1	*€ 0,113 M*
3. GMOS, Contr. 265113, ENV.2010. 4.1.3-2	*€0,091 M*
4. Grant nr.247475, FP7-PEOPLE-IRSES-2010, COLIMA	*€0,081 M*
5. FP7.-2011, PEOPLES-IRSES; NOCTURNAL ATMOSPHERE, Grant Nr. 294949	*€055 M*
6. FP7.-2012, PEOPLES-IRSES. Grant *, Nr.316177, BIOSENSORS-AGRICULT*	*€0,057 M*
7. III LASERLAB-EUROPE, Contr.Nr.284464, INFRA-2011-1.1.19	*€0,0 90 M*
8. *BiophotonicsPlus*; FP7-ICT-2011-8, Grant. Nr. 318669;	*€0,146 M*
9. FP7-PEOPLE-2013-IRSES, grant 612691, Refined Step	*€o,1M*
10. FP7-PEOPLES 2008-cIG ”QAQC, Nr.224886	*€0,1M*
11. QCS, 55961-2, ICT-2009.8.0 FET-Open	*€0,4M*
12. FP7,IST,RAQUEL,, 323970-2	*€0,27M*
13. QALGO, Nr. 600700, ICT-2011-FETopen	*€0,45M*
14. MQC,320731, Contr. nr.ERC-AG-PE6	*€1,36M*
15. ICT-10-9.7 - FET Proactive: 610637	*€0,2M*

University of Latvia is among the world leaders in the theory of quantum computing, as witnessed by Latvia’s first grant from the European Research Council, the organization that supports Europe’s leading scientists and FP7 projects (QCS, QALGO) where University of Latvia is coordinating consortia consisting of organizations from 7 countries including the world-renowned institutions such as Cambridge University.

There are more than 12 SMEs in Latvia and Lithuania in the area of photonics and laser technologies that are competititve worldwide and have annual turnover more than *€2,0MEur* in 2013[4]

[3] FOTONIKA-LV & Z-LIGHT. The 1st interactive workshop for cooperation PHOTONICS AND QUANTUM TECHNOLOGIES, LIVANI, LATVIA 25.082013; The 1st Baltic Countries regional workshop. Inventory of capacity: Human resources; Industry; Intelectual Capital and IPR assets, Riga July 26, 2013; Photonics, Quantum Sciences and technologies in Baltic countries. The 1st regional workshop on strategy planning and technology foresight, Riga October 11-13, 2013;
PHOTONICS, QUANTUM SCIENCES AND TECHNOLOGIES, LATVIAN CONTRIBUTION TO ERA AND EUROPA 2020. DISCUSSION – TOWARDS REGIONAL SMART SPECIALIZATION, 25.09.2013. RIGA, LATVIA, EUROPA HOUSE, EU DELEGATION IN LATVIA
The 1ST Baltic Photonics Innovation workshop. Challenges for the Photonics community in Estonia, Latvia and Lithuania, Dec.16, 2013.

*[4] In **Latvia** this includes: Z-LIGHT LTD, www.Z-Light.lv: GroGlas LTD, http://www.groglass.com/; Sidrabe LTD, http://www.sidrabe.com/; ISPoptics LTD, www.ispoptics.com/; Baltic Scientific Instruments LTD, www.bsi.lv; OPTRON, LTD, http://www.optron.lv; in **Lithuania:** LIGHTCON LTD, http://www.lightcon.com/; EKSPLA, LTD, http://www.ekspla.com/; STANDA, LTD, http://www.standa.lt/; EKSMA,LTD, http://www.eksma.lt; ALTECHNA, LTD, Workshop of Photonics,*

Association FOTONIKA-LV in the Global network in Geosciences and Satellite Ranging Technologies

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The Association FOTONIKA-LV has an objective to work towards the New Performance of Distance Measurements in Satellite Laser Ranging – Advancement of Technologies Contributing to the Earth Sciences and basing on broad network of partnerships to strengthen and to contribute in upgraded the network of 1 m aperture Satellite Laser Ranging (SLR) telescopes in Eastern Europe and neighbouring countries. We intend to enhance existing named ILRS (*International Laser Ranging Service*) stations which for various reasons lag behind the ILRS network core stations in their performance.

Researchers in the institutes associated by FOTONIKA –LV has more than four decades of experience and expertise in the SLR technology design[5],[6], [7]

The first important practical aspect is to perform an inventory of the partners' SLR stations currently included and those stations not included in the ILRS net or not fully utilizing the potential of named stations. Based on acquired new knowledge, partnerships and the inventory provided by this proposal, it is planned to raise future projects for the upgrade of the SLR stations in the way that they will reach the maximum of their deliverable accuracy and in addition it is planned to include these upgraded SLR stations in the ILRS net[8]. A challenge to tackle is how in a most efficiently way take the opportunities offered by the latest achievements in Laser Technologies[9], Timing Technologies and Geodesy-Geoid research in order to extend present level knowledge and skills and as a result create a "critical mass" of human capacity. This obtained capacity is also needed to contribute to future advancements in ranging different space objects like space debris, dangerous asteroids, ranging of the surface of the Moon, and other future space exploration challenges.

The spectral properties of space objects are among the study with SLR technologies interests of consortium researchers.

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Digitized Schmidt telescope data in the path of the international Virtual Observatory

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The archive of the astronomical photos taken with the Baldone Schmidt wide field telescope of the Institute of Astronomy of the University of Latvia (up to 1 July 1997 – Radioastrophysical observatory of the Latvian Academy of Sciences) in the period 1967-2001. The archive contains more than 22000 direct and 2300 spectral photos of various sky regions. The Baldone Schmidt telescope (80/120/240 cm) was put into operation in December 1996 on the hill Riekstukalns $\lambda = +24°24'.0$, $\delta = 56°47'$, height over the sea level h = 103 m) near Baldone town. The telescope still ranges among the 12 biggest wide field Schmidt telescopes in the world. Every photos of Badone Schmidt telescope cover the field of 4°46' in diameter, but the size of photo plates is 24x24 cm.

The digitalization of astronomical photos was begun at 2012 with flat bed scanner Epson Express 10000XL. To now more than 4000 photos were digitalized. Scanned image dimensions of one photos is 21640x21644 pixels, and takes ~920Mb. For the data processing the standard IRAF (Image Reduction and Analysis Facility) program package was fitted. The other way is explore the Centre de astronomique de Strasbourg-Done options to access of astronomical data centre, as well as treatment of software package Aladin, for the ability to make astronomical image calibration and identification of objects.

The information and the acquisition of the virtual observatory in the Ukraine, and the successful integration of the international Virtual Observatory Alliance (IVOA) was exchanged and will use this experience to the creation of the virtual observatory in Latvia.

Stochastic Ionisation Analysis for Hydrogen Atom in External Microwave Electric Field on the Base of Split Operator Technique

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One of the physical problems manifesting strong stochastic properties is a model of a Rydberg atom in an external microwave electric field. Under conditions of a dynamic chaos regime we consider a diffusion ionization of the hydrogen atom. The ionization rate of Rydberg atoms interacting with the microwave field is defined not only by one-dimension Rydberg electron energy dynamics, as was supposed in earlier studies [1], but its angular moment dynamics as well. We have improved split operator technique described in [2] for stationary systems having extended it to important class of non-stationary problems - such as alkali atoms in alternating electric and magnetic fields. Split operator method and Floquet technique [3] allow us to perform numerical calculations with high accuracy in the case when standard methods of numerical integration of classical equations of motion, like Runge-Kutta method, appear to be unsatisfactory.

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Self-quenching cross sections and radiative lifetimes for potassium nS and nD states

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We report first measured and calculated cross sections for self-quenching in thermal collisions of potassium Rydberg atoms. The experiment was performed for some lower n^2S ($7 \leq n \leq 10$) and n^2D ($5 \leq n \leq 8$) states in vapour-cell conditions. The K-atom vapour temperature was varied in the range of 400-450K (atomic number densities 0.1 – 1.7x10^{13} cm^{-3}). Time-resolved pulsed-laser induced fluorescence was analysed. Along with the self-quenching cross sections, natural lifetimes of the states, were also measured. The cross sections were calculated for the states with *n* up to 50 by using the Fermi pseudopotential model combined with semiclassical impact parameter approach for the potential scattering and by using impulse approximation for the resonance scattering within the framework of the quasi-free electron model. A good agreement between the measured values and the corresponding theoretical predictions was achieved**.** The determined lifetimes are discussed as compared to the relevant measured and calculated values known from the literature.

Study of STIRAP efficiency of helium Rydberg atoms in supersonic beams

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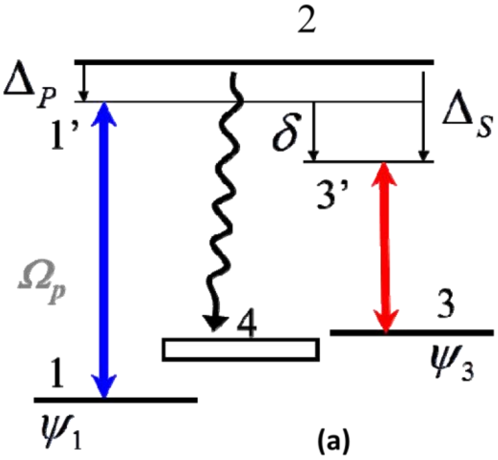
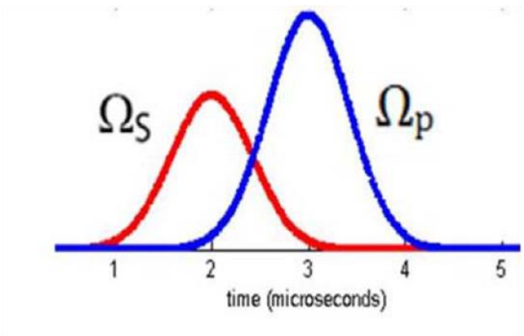
We study the Stimulated Rapid Adiabatic Passage (STIRAP) for Metastable Helium atoms. In our experiment, we populate the n=24 Rydberg state via the intermediate 3P triplet state by a sequence of two lasers at ≅796nm and ≅389nm separately in the counter-intuitive order as suggested by STIRAP. In our earlier studies [1] we have reached some very interesting observations from this experiment. The STIRAP method has not achieved the 100% efficiency for the n=24 Rydberg atom production, but rather much lower. In current study we are trying to discover the new physics lying behind that. Henceforth, we setup Linkage diagram and Schrödinger equation (in atomic units) and solve the equation using Airy function.



(a)



(b)

Fig.1. (a) Conventional STIRAP construction for lambda-scheme. (b) The STIRAP pulses sequences.

In Fig.1 the one - (Δ_p), and two - ($\delta=\Delta_S-\Delta_p$) photon detunings relate to energies of the bear states 2 (Ψ_2) and 3' (Ψ_3) provided that the energy of the bear state 1' (Ψ_1) is taken to be zero.

The new basis of the dark Ψ_D and the bright Ψ_{Br} states

$$\Psi_{Dark}= \cos(\theta)\,\Psi_1 - \sin(\theta)\,\Psi_3 \qquad \sin(\theta) = \Omega_P/\Omega_C, \qquad (1)$$

$$\Psi_{Bright}= \sin(\theta)\,\Psi_1 + \cos(\theta)\,\Psi_3 \quad \text{with} \quad \Omega_P = \mathrm{sqrt}(\Omega_P^2+\Omega_S^2), \qquad (2)$$

allows to provide the diagonalization of the atom-lasers interaction operator Â

$$<\Psi_2|\,\hat{A}\,|\Psi_{Dark}>=0\ ; \quad <\Psi 2|\,\hat{A}\,|\Psi_{Bright}>=\Omega_C/2\ ,$$

but does not bypass the off diagonal elements resulted from the bear atomic energies $\hat{H}_a$ and nonadiabatic coupling operators

$$\Omega_{BD} = <\Psi_{Bright}\,|\,i\partial/\partial t+\hat{H}_a\,|\,\Psi_{Dark}> = i\partial/\partial t\theta - \delta\sin(2\theta)/2. \qquad (3)$$

We consider a situation when the initial ($t=-\infty$) population can be associated with the dark state $\Psi_{Dark}=\Psi_1$ (when θ=0) and are concerned with its (Ψ_{Dark}) population lack due to the coupling Ω_{BD}.

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Storage Time Of Cold Rb Atoms In An Optical Dipole Trap Formed By A Multimode Fiber Laser

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We systematically studied the storage time of ^{87}Rb atoms in an optical dipole trap formed by a multimode fiber laser[1]. Storage time is an important parameter in cold atom experiments. However, if atoms are prepared in all Zeeman sublevels of the hyperfine state |F=2>, hyperfine-state-changing collisions can transfer these atoms from |F=2> to |F=1>, whereby the released kinetic energy leads to considerable trap loss. Furthermore, if atoms are prepared in the hyperfine state |F=1>, two-photon Raman transitions induced by high-power multimode fiber lasers can optically pump these atoms from |F=1> to |F=2> and the following hyperfine-state-changing collision results in the trap loss. In this work, our experimental data indicate that these trap losses can be inhibited if the atoms are prepared in the single Zeeman sublevel of |F=2,m=2> or |F=2,m=-2> and an auxiliary magnetic field is applied.

References

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Earth's surface movements in Latvia

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For more than two decades, Global Navigation Satellite Systems (GNSS) have played a central role in understanding the movements of the Earth's surface. Continuously operating base stations have recorded GNSS data. The data have been collected and processed to provide precise information on the continuous changes of the GNSS station positions.

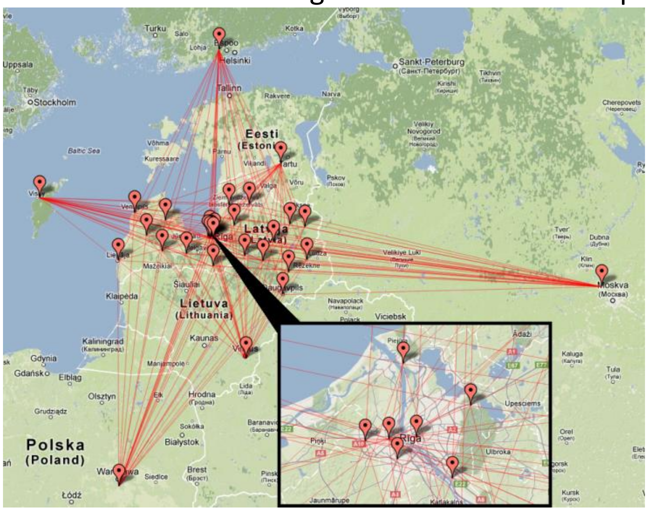

Fig.1. LatPos and EUPOS®-Riga network solution with reference stations from EPN: JOZE, MDVJ, METS, RIGA, TORA, VIS0, VLNS.

The GNSS observations of both EUPOS®-Riga and LatPos permanent networks have been collected for 7-year period – from the year 2007 to 2013. With the reference stations from EUREF Permanent Network (EPN) in surroundings of Latvia and the input data sets from International GNSS Service's (IGS) data bases, the *Bernese GPS Software* Version 5.0 has been used to compute daily network solutions (Balodis 2011). As a result of post-processing computation the coordinate time series of all Latvian GNSS stations have been obtained [1].

The analysis of possible dependences between changes of GNSS station positions and different impact sources has been performed. The main factors which have been suspected are reference station problems, soil moisture content changes, and seismic activity of some areas of Latvia with local engineering-geological conditions which may increase the Earth's surface oscillations. As well as the impact of solid Earth tides and solar activity has been considered. The principal focus is on the site displacement identification excluding noises of obtained GNSS time series.

The data growing amplitude and periodic variations were identified for obtained coordinate series. From the year 2008 Latvian GNSS station Up-differences have been increasing, that might be caused by raising solar activity. To demonstrate oscillations in the coordinate time series the autocorrelation and spectral density functions have been used. As well as a distinctive behaviour of site coordinate changes was identified for some of EUPOS®-Riga and LatPos stations.

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Satellite Laser Ranging and Air traffic Interaction Monitoring

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Since the commercial introduction of high power laser pointers, the number of incidents when an aircraft cockpit has been illuminated either accidentally or on purpose has increased significantly. As a consequence, to manage this situation, in several countries legislation and controls has been introduced to limit laser outdoor use and energy. While there are no recorded incidents involving SLR stations, they had to upgrade its hardware and software to comply with the new regulations. These upgrades include use of various options - radar, controlling laser energy, visual control during the station operation, air traffic control receivers (ADS-B) and specialised information from air traffic authorities.

Riga SLR station during the 4th quarter of 2013 has installed a Kinetic SBS-3 ADS-B receiver and day/night camera to view the region in the sky around the outgoing laser beam. The next generation telescope control software will use the information from ADS-B receiver to visualise planes tracks on control computer's display and also to control the laser transmission.

In November 2013 at the 18th International Workshop on Laser Ranging in Fujiyoshida, Japan our proposal to create a global database of all SLR/Air traffic Interactions was accepted. The database will include registered cases form global network when the station SLR laser beam come close to plane as recorded by the SLR station's safety system. During 2014 it is expected to organise a working group, define the data format and standards for such a database. Preliminary results will be presented at the 19th International Workshop on Laser Ranging in Goddard Space Center, Maryland USA in October 2014.