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73rd Annual Scientific Conference
of the University of Latvia

Section:
The Project "FOTONIKA-LV – FP7-REGPOT-CT-2011-285912"
The Third Year Scientific Outcomes

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Riga Photonics Center
Skunu street 4, Riga, Latvia

BOOK OF ABSTRACTS

INTERNATIONAL
YEAR OF LIGHT
2015

Supported by FP7 project

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

FP7-REGPOT-CT-2011-285912

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INTRODUCTION

This book of abstracts of the 73rd Annual Scientific Conference of the University of Latvia is for the Section of the Conference devoted to "The project 'FOTONIKA-LV – FP7-REGPOT-CT-2011-285912 – the *third* – year scientific outcomes". It summarizes results of scientific research as well as other project implementation activities that will be reported in the third FOTONIKIA-LV Section conference on February 6, 2015. The first FOTONIKA-LV Section Conference was held on February 1, 2013 part of the 71st and the second was on February 7, 2014 as part of the 72nd annual LU Conference.

The FOTONIKA-LV Section of the 73rd LU Conference is the first scientific event in Latvia highlighting RTD activities in the photonics domain in Latvia during the International Year of Light and Light-based Technologies *(IYL 2015 proclaimed by the United Nations (UN) General Assembly 68th Session on 20 December 2013)*.

The FOTONIKA-LV project will be completed by mid-2015. The three books of abstracts will be followed by the publication of the proceedings of the conference planned for April 23-24, 2015 to mark the fifth anniversary of the Association FOTONIKA-LV founded on April 24, 2010. The proceedings of this anniversary conference will cover a review of research results and the future outlook of the FOTONIKA-LV association.

The abstracts provide insight in the RTD activities of the research staff of the three institutes comprising the FOTONIKA-LV association of the University of Latvia *(The Institute of Atomic Physics and Spectroscopy, the Institute of Astronomy, and the Institute of Geodesy and Geoinformatics)* during the previous 12 months taking advantage of opportunities opened by the FOTONIKA-LV – FP7-REGPOT-CT-2011-285912 project aimed to unlock and boost the Latvian R&D potential for photonics, quantum sciences, space sciences and related technologies.

The range of the abstracts demonstrates the persistent efforts of the FOTONIKA-LV community to enhance research and outreach activities in various fields related to photonics including optoelectronics, atmosphere and space sciences, astronomy, Earth geodesy, laser ranging and remote sensing, atomic, molecular, and ion physics; quantum optics; and bio-photonics. Success is significantly based on collaboration spanning the European-research area (ERA) and worldwide with colleagues from strategic partnership institutions in more than 20 countries. FOTONIKA-LV work has also contributed to the success of research-driven SMEs in photonics and spaces technologies achieved in spite of insufficient national funding with its very adverse impact on Latvia's RTD sector.

During 2014 the FOTONIKA-LV community used a bottom-up process to convincingly demonstrate that the smart specializations of Latvia includes photonics framing quantum sciences, space sciences and related technologies. What is urgently needed is a national and pan-Baltic RIS3 strategy to take advantage of significant potential for photonics to drive innovation and economic development. Letters presenting this position were sent to the Prime Minister of Latvia and her counterparts in Estonia and Lithuania as well as to authorities in the European Commission, parliament, scientific organizations and other decision makers.

In part this was to ensure the opportunity for researchers in photonics (framing the domains of quantum sciences, space sciences and related technologies) to successfully apply for Horizon 2020 funds that often have the ex-ante conditionality that the project must link to the smart specialization of the region to receive funding. The analysis of the research performance and economic impact of the photonics, quantum sciences and space sciences and related technologies cluster was also undertaken to inform decision makers of the importance of photonics and related disciplines to the future of the economy of Latvia.

Dr. Arnolds Ubelis
Scientific Secretary of the Association FOTONIKA-LV
at the University of Latvia

PROGRAMME

Registration 8:30-9:00
Auditorium at 4th Floor

Oral Session 1 – Report on Outcomes of Work packages of project FOTONIKA-LV
Chair A. Ubelis
Auditorium at 4th Floor

1	9:00-9:10	A. Ubelis	Overview of FOTONIKA-LV Project and its Results
2	9:10-9:20	S. Smalina	Results of WP1 – Partnerships, Exchange of Know-how and Experience
3	9:20-9:30	K. Salmins	Results of WP2 – Repatriation and Recruitment of Experienced Researchers
4	9:30-9:40	E. Smalins	Results of WP3 – Upgrading, Development or Acquisition of Research Equipment
5	9:40-9:50	D. Berzina	Results of WP4 – Knowledge Transfer and Training, Organisation of Workshops, Conferences and Summer Schools
6	9:50-10:00	A. Atvars	Results of WP5 – Dissemination, Promotion, Contribution to Innovation – Public Access Riga Photonics Centre

Oral Session 2 – Scientists Recruited from Abroad by FP7 FOTONIKA-LV Project
Chair V. Beldavs
Auditorium at 4th Floor

7	10:00-10:15	R. Viter, M. Bechelany, U. Riekstina, N. Starodub, D. Erts, V. Smyntyna, I. Yatsunskiy, A. Ubelis	Development and Application of Novel Photonic Materials
8	10:15-10:30	J. R. del Pino, K. Salmins, M. Abele, A. Meijers, I. Lyubych, S. Horelnykov, V. Zhaborovskyy	New Calibration for the Riga SLR Station
9	10:30-10:45	T. Kirova, D. K. Efimov, K. Miculis, E. Stegenburgs, M. Bruvelis, A. Cinins, N. N. Bezuglov, I. I. Ryabtsev, A. Ekers	Manifestation of Multiple Dressed States in Hyperfine Levels of Na: the Death of Dark and Some Bright Components in Autler-Townes Spectra

10:45-11:15 Coffee break

Oral Session 3 – Scientists Repatriated from Abroad by FP7 FOTONIKA-LV Project
Chair A. Ubelis
Auditorium at 4th Floor

10	11:15-11:30	J. Alnis, I. Brice, J. Rutkis, I. Fescenko, C. Andreeva	Measuring Rubidium Optical Transitions with a Femtosecond Frequency Comb
11	11:30-11:45	V. Beldavs	The International Lunar Decade: A Giant Leap Forward in Understanding the Moon and Opportunities for its Development
12	11:45-12:00	J. Blahins	Transfer of Emerging Technologies by LU Association FOTONIKA-LV
13	12:00-12:15	I. Fescenko, A. Weis	Visualizing Magneto-Optical Effects by Bright and Dark Atoms

12:15-13:15 Coffee break, Lunch break

Oral Session 4 – SECONDMENT Visits within FP7 FOTONIKA-LV Project
Chair I. Eglitis
Auditorium at 4th Floor

14	13:15-13:30	I. Eglitis	Secondment visit in Moletai Observatory, Institute of Theoretical Physics and Astronomy, Vilnius University
15	13:30-13:45	K. Salmins, J. del Pino, E. Hoffman	Modernization of SLR Station Riga and Future Prospects
16	13:45-14:00	J. Blahins, A. Apsitis, V. Silamikelis	Results on Secondment Visits to Belarus and Crimea

Oral Session 5 – Reports of Institutes on Impact from FP7 FOTONIKA-LV project
Chair A. Atvars
Auditorium at 4th Floor

17	14:00-14:15	I. Eglitis	Overview of Impact of the FOTONIKA-LV Project on the Institute of Astronomy
18	14:15-14:30	G. Silabriedis, J. Balodis, A. Zarins, A. Rubans, I. Janpaule, D. Haritonova, I. Lasmane	Overview of Impact of the FOTONIKA-LV Project on the Institute of Geodesy and Geoinformatics
19	14:30-14:45	J. Alnis	Overview of Impact of the FOTONIKA-LV Project on the Laboratory of Quantum Optics, Institute of Atomic Physics and Spectroscopy
20	14:45-15:00	A. Ubelis	Overview of Impact of the FOTONIKA-LV Project on the Laboratory of Atomic Physics, Atmospheric Physics and Photochemistry, Institute of Atomic Physics and Spectroscopy

Coffee break 15:00-15:30

POSTER SESSION 15.30-17.00

Chair A. Atvars, assistant D. Ubele

Auditorium at 1th Floor

P1	C. Andreeva, A. Cinins, A. Ekers, D. Tretyakov, V. Entin, E. Yakshina, I. Beterov, A. Markovski, I. Ryabtsev	Controlling the Interaction of a Few Cold Rb Rydberg Atoms by Radio-Frequency Assisted Förster Resonances
P2	A. Atvars	TRIZ Tools for Inventive Problem Solving
P3	A. Atvars, V. Beldavs	Report on the Conference "The Next Giant Leap: Leveraging Lunar Assets for Sustainable Pathways to Space", Hawaii Island, USA, November 9-13, 2014
P4	V. Beldavs	Cooperation in Space Technologies with Africa
P5	V. Beldavs	FOTONIKA-LV and the International Year of Light
P6	I. I. Beterov, A. Markovski, S. M. Kobtsev, E. A. Yakshina, V. M. Entin, D. B. Tretyakov, V. I. Baraulya, I. I. Ryabtev	A Simple Cost-effective Digital System for Tuning and Long-Term Frequency Stabilisation of a CW Ti:Sapphire Laser
P7	N. N. Bezuglov, T. Kirova, A. Ekers, N. Porfido, S. Birindelli, F. Tantussi, F. Fuso	Nonlinear Optical Pumping of a Slow and Cold Cs Beam
P8	J. Blahins, A. Apsitis, S. Gorbatov, F. Pliavaka, K. Gross	Concept Project of Microwave Plasma Torch Based 3-D Printer for Hard Melting Materials
P9	I. Brice, J. Alnis	GNSS More than a Tool for Navigation
P10	K. A. Gross, A. Ubelis, D. Ubele	The FOTONIKA -LV Project "An international Network on New Strategies for Processing of Calcium Phosphates", FP7-PEOPLE-2013-IRSES, g/a 612691 (01.12.2013-30.11. 2017)
P11	D. Haritonova	Earth Tide Observations and Analysis Methods
P12	D. K. Efimov, N. N. Bezuglov, K. Miculis, A. Ekers	Penning Ionization of a Non-symmetrical Atomic Pair in a Rydberg Gas
P13	J. Rutkis, J. Alnis	Dust Particle Counting in Ambient Laboratory Air
P14	A. Treijs, J. Vjaters, M. Abele, E. Rutkovska,	Development of Laser Beams Coaxial Direction Active Stabilization on Interoperable Remote Platforms
P15	A. Ubelis, M. Abele, J. Vjaters, K. Salmins, I. Eglitis, K. Michulis, V. Silamikelis	The FOTONIKA-LV Project "NOCTURNAL ATMOSPHERE", FP7-PEOPLE-2011-IRSES, g/a 294949 (01.02.2013-31.01.2017)

CONTENTS

Results of WP 1 – Partnerships, Exchange of Know-how and Experience

S. Smalina, WP 1 leader

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The exchange visits included in this work package are intended to ensure further development of the existing cooperation of FOTONIKA-LV with its strategic partners as well as initiation and development of new partnerships with the purpose of advancement of basic research and technology development.

The following objectives were met during implementation of Work Package 1:

1. Strategic partnerships with 10 leading European research centers were strengthened through trans-national two-way secondments of research staff;
2. New cooperation initiatives were developed with 31 advanced research institutes through two-way secondments.
3. Basic and applied research experience was shared resulting in joint publications and new technology developments relating to these and other themes: cutting-edge photonics problems including theory of atomic processes in high-power laser fields, bio-photonics, plasma spectroscopy and photonics, development of innovative light sources, satellite laser ranging, remote optical sensing in atmosphere, and other research;
4. Mobility of young and established researchers of the FOTONIKA-LV community was facilitated, developing competence and expertise in photonics through visits and contacting colleagues at leading EU centers;

During the project *(01.02.2012-31.01.2015*) 97 secondment visits were performed. There were nearly 57.1 person months of secondment visits from which 25 months and 19 days were secondments with strategic partners and 31 month and 11 days were secondments with emerging and new partnerships.

Secondment visits by project periods identified by incoming and outgoing visits are shown in the table below.

Table.1. Secondment visits project FOTONIKA LV period 01.02.2012.-31.01.2015.

	Total	Existing Partnerships WP1.1		Emerging partnerships WP 1.2.	
		Incoming	Outgoing	Incoming	Outgoing
1st period number of visits	53	11	18	9	15
Person month	36,9	1,79	13,4	9,21	12,5
2nd period number of visits	43	16	7	13	7
Person month	19,7	6,5	3,5	4,7	5
TOTAL in PROJECT					
VISITS	96	27	25	22	22
Person month	56,6	8,29	16,9	13,91	17,5

The secondment visits contributed towards increasing the "critical mass" of intellectual capacity for the defined scientific tasks and provided significant synergy resulting in increased scientific productivity.

Table 2 and Table 3 list institutions with which secondment visits were performed.

Table 2. Strategic partnerships secondment visits in Project FOTONIKA LV

	Strategic partner	**Country**
1	Geo Forschungs Zentrum Potsdam, *www.gfz-potsdam.de*	Germany
2	The Finnish Geodetic Institute, *www.fgi.fi/i*	Finland
3	Lund Laser Centre, Lund University, *http://www-llc.fysik.lth.se/*	Sweden
4	Lund University Hospital, Division of Oncology	Sweden
5	Gothenburg University Physics Department	Sweden
6	Laser Research Centre, Vilnius University, (VU LRC) *http://www.lasercenter.vu.lt/*	Lithuania
7	University of Kaiserslautern, *www.physik.uni-kl.de/bergmann/*	Germany
8	Karlsruhe University of Applied Sciences (HSKA) Faculty of Information Management and Media	Germany
9	Institute of Biomedical Engineering, Linköping University, *http://www.imt.liu.se/index.en.html*	Sweden
10	Institute for Low Temperature Plasma Physics at Ernst Moritz Arndt University in Greifswald, *www.uni-greifswald.de/*	Germany

Table 3. Emerging and new partnerships during project FOTONIKA-LV

	Emerging partnerships	**Country**
1	Institute of Theoretical Physics and Astronomy, Vilnius University (*G. Tautvaisiene, Z. Rudzikas*) – intensification of cooperation;	Lithuania
	Institute of Oncology, Laboratory of Biomedical physics, Vilnius University	
	Laser Research Center, Biophotonics group, Vilnius University	
	Physics Faculty, Department of Quantum Electronics, Vilnius University	
	Vilnius Gediminas University Faculty of Environmental Engineering	
	Moletai Observatory Institute of Theoretical Physics and Astronomy, Vilnius University	
2	Max Planck Institut für Chemie, Mainz (T. Wagner) – intensification of cooperation	Germany
3	The Fraunhofer Institute for Systems and Innovation Research ISI (ISI *http://www.isi.fraunhofer.de/*), Karlsruhe (Univ-Prof. Dr. Marion A. Weissenberger Eibl) – development of new cooperation for new leaders training in science management and applications	Germany
4	Space Research Center Polish Academy of Science	Poland
	Institute of Physics of the Polish Academy of Sciences	Poland
5	University of Oulu, Optoelectronics and Measurement Techniques Laboratory; *http://www.ee.oulu.fi/research/oemlab/index_eng.html*	Sweden
	University of Oulu, Electronic spectroscopy group	Sweden
6	Institute of Semiconductor Physics, Novosibirsk, Russia, www.isp.nsc.ru	Russia
7	Fock Institute of Physics, St. Petersburg State University, Russia, *www.niif.spbu.ru/*	Russia
8	Gdansk University of Technology, Faculty of Applied Physics and Mathematics,	Poland
9	Lomonosov State University, Moscow	Russia
10	Stockholm University, Department of Physics	Sweden

	NEW partnerships	Country
11	National Institute for Theoretical Physics	South Africa
12	Austrian Institute of Technology	Austria
13	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE European Institutes of Membranes, Montpellier, France	France
14	Ultracold Atom Laboratory, National Tsing Hua University, Department of Physics Hsinchu	Taiwan
15	Institute of Electronics, Bulgarian Academy of Sciences	Bulgaria
16	Aalborg University, Faculty of Engineering and Science, Department of Development and Planning, Danish GPS Center	Denmark
17	Stony Brook University, Department of Physics	USA
18	Swiss Federal Institute of Technology Zurich	Switzerland
19	European Photonics Industry Consortium – EPIC Association	Belgium
20	Stockholm University, Physics Department,	Sweden
21	Oak Ridge National Laboratory (USA)	USA
22	National University of Life and Environmental Sciences of Ukraine	Ukraine
23	Austrian Institute of Technology, Vienna, Austria	Austria
24	Université de Fribourg, Département de physique	Switzerland
25	University of Pisa	France
26	Aeonyx Research Corporation, Aeonyx Photonics Divisio	USA
27	Physical Research Laboratory, Space and Atmospheric Science Division, (INDIA)	India
28	St. Petersburg State Polytechnic University, Faculty of Physics	Russia
29	National Tsing Hua University, Taiwan	Taiwan
30	Amsterdam University, Korteveg – de Vries institute of Mathematics	Netherlands
31	Indian Institute of Teacher Education (Gandhinagar, Gwarat, India), Centre of Education, Department of Physic	India

Results of WP2 – Repatriation and Recruitment of Experienced Researchers

K. Salmins, WP 2 leader

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This paper discusses the results of Work Package 2 – recruited and repatriated scientists and their contribution to the Association FOTONIKA-LV covering new research directions, projects and synergies. Some examples of work performed include establishing the Laboratory of Quantum Optics, evaluation of the possibility to use laser frequency combs to measure distances to satellites, night atmosphere spectroscopy, among others. Probably the most significant result is increased scientific capacity of the Association and knowledge sharing including technical "know-how" among the scientists involved in the project.

The following recruited and repatriated scientists were employed in 2014:

1. Dr. Nikolai Bezuglov, theoretician in atomic and molecular physics,
2. Dr. Teodora Vecheva Kirova, theoretician in atomic and molecular physics,
3. Dr. Asparuh Georgiev Markovski, researcher in mathematical modelling and programming,
4. Dr. Christina Andreeva Markovska, researcher in atomic and molecular physics,
5. Dr. Jorge Roberto del Pino Boytel, researcher in satellite laser ranging,
6. Dr. Roman Viter, researcher on biosensors,
7. Dr. Amara Graps, researcher in astronomy and space science,
8. Dr. Janis Alnis, the leader of the laboratory of quantum optics,
9. Dr. Ilja Fescenko, researcher in a laboratory of quantum optics,
10. PhD candidate Janis Blahins, technician and researcher in atomic and molecular physics,
11. Dr. Aigars Ekers, the leader of the molecular beam laboratory,
12. Dr. Arvind Saxena, researcher in atomic and molecular clusters.

Results of WP 3 – Upgrading, Development or Acquisition of Research Equipment

E. Smalins, WP 3 leader

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WP 3 in the Project FOTONIKA LV was designed to answer the needs for upgrade of the existing research infrastructure via replacement of outdated equipment, purchase of new components and modules, and developing new apparatus to replace the old equipment. Such upgraded infrastructure will ensure that the human potential gained via recruitment or repatriation of researchers has been placed in the *state-of- the-art* environment enabling them to efficiently perform research. Furthermore, condition of the infrastructure is also an important precondition for the achievement of full mutual benefit from cooperation with partnership organizations and secondments organized in WP 1.

The following tasks were accomplished during project implementation:

Task 3.1. Equipment to develop a lab made working model device for night-time cartography of atmosphere by exposing satellite instruments with a white light beam from the Earth's surface

Optical lens kit for Schmidt telescope optical channel was purchased. This improvement will allow of a small part of curved focal plane image carry out of tube where it will be perceived with the CCD. Two that channels increase the effectiveness of observations with telescope more than 30 times.

Task 3.2. Development of satellite laser ranging systems towards application of femtosecond lasers and frequency combs

Femtosecond laser system is used for optical frequency standards, remote sensing and laser ranging. It is emitting a rainbow of colors in the range 500...1000 nm. Frequency comb has applicability in bio-optics research, for example skin fluorescence after illumination with fs pulses, and could be used for cancer diagnostics.

Task 3.3 Upgrade of laser equipment of the molecular beam laboratory of the repatriated researcher Dr. A. Ekers

The key components of the purchased tunable single frequency laser system with frequency doubling were purchased. The laser system including optical components and fibre couplers have been installed in the laboratory, fundamental Ti:Sa laser radiation of up to 6W in single frequency and second harmonic radiation of op to 500mW are available for experiments. Laser system upgrade provides wider range of laser frequencies and higher laser output power. An essential improvement is that the new laser systems enable the achievement of higher Rabi frequencies in experiments, which in turn ensures the right experimental conditions for the achievement of well-resolved interference fringes.

Task 3.4. Upgrade of UV and vacuum UV, spectroscopy instrumentation, and linked quartz & glass blowing workshop and technology laboratory and development of far UV laser spectroscopy

There are purchased parts for a vacuum spectrometer Mc Person 234/302. Spectrometer can record spectra in the range from 37nm -151nm at the same time, which allows performing complex and effective research of UV sources and respective radio frequency excitement generators.

Task 3.5. Upgrade of biophotonics research facilities

Mixed signal oscillograph (MSO4054B) was purchased. It is used for autofluorescence lifetime measurements of skin. The lasers and lasers' controller comprise one system. With this equipment the three wavelengths we worked before, measured autofluorescence photo bleaching.

Photon counting detector, detector's controller, data processing system, SPC-150 is one system for photon counting and time-correlating; with the minimum requirements for lifetime imaging.

Task 3.6. Advanced upgrade of research equipment for Fundamental Geodynamical Observatory

Purchased equipment allowed restoring existing SLR system functionality and now it's possible to take steps to participate in upcoming projects such as space debris tracking.

The most important result is restoring SLR system functionality and several of its subsystems were improved. Redesigned SLR system calibration – calibration RMS now is about 7ps instead of 14ps, also it is now more stable. Fully upgraded time and frequency system now features GPS steered Rb oscillators and OXCO slave clocks connected with fiberoptic and coaxial cables. Timing system clocks were evaluated and compared with primary cesium time standards at GFZ Potsdam, Germany. Redesigned telescope alignment instrumentation is using stable 532nm laser diodes. Construction of new combined visual tracking/receiver channel unit is currently under way. New unit will allow to use additional detectors like SPAD will use CCD for tracking.

Task 3.7. Advanced upgrade of the largest wide field Schmidt telescope in the Baltic States

Flatbed scanner complex needed to digitalize the wide field Baldone Schmidt telescope astronomical plate archive from the 1966-2005 time period. The uniqueness of this archive is record of regular observations almost 40- year long period toward constellation of Swan and anticenter of Galaxy directions. Digitization will give a high volume database which will allow to explore the brightness variability of stars of different spectral types in long time span, to measure the intrinsic speed of stars, and to discover new asteroids and comets.

Task 3.8. Zenith Refractometer

The Zenith refractometer used in the Laboratory of the Institute of Geodesy and Geoinformatics was upgraded with:

1. Equipment for mobile computerized large volume data flow registration in field conditions is necessary. A laptop computer was purchased for this purpose that will also be used for mechanical component design and associated calculations using Solid Edge software package and for device control and data acquisition software compiling.
2. SBIG CCD matrix will be used for star field image acquisition, necessary to calculate accurate instrument orientation, relative to coordinate system, defined by reference stars.
3. Hemisphere GPS A325 will be used to determine an accurate instrument position in geocentric coordinate system and .time of star imaging events.

Tripod and a number of mechanical and electronic components will be used for instrument assembly, power supply, data flow support and control functions.

Task 3.10. Advanced upgrade of electron-beam and resistive evaporation of dielectric, semiconductor and metal multilayer achromatic optical coating installation – VU-2M for interference mirrors and filters etc. (250-1100 nm) with simultaneous photometric layer testin

For general air inlet to cleanroom where the sputtering laboratory will have processing machinery, calculated in accordance to standards for cleanrooms HVAC systems.

At this time we have a small test deposition apparatus whose construction was used as student graduation exercise. As soon as possible we plan to process several astronomical mirrors and many more in the future. We plan to be able to produce optical equipment in small series on demand. We plan to install the negative ion research apparatus GRIBAM in the hall next to the cleanroom with the crystal growing apparatus with zone refinement regime, and use the semi-clean zone for constructing and adjusting the ion implantation instrument while it remains in our facility. Subsequently the implanter location will be occupied by a special laser or precision frequency comb instrument. The cleanroom will be permanently occupied with three deposition devices and sample cleaning equipment.

Results of WP 4 – Knowledge Transfer and Training, Organisation of Workshops, Conferences and Summer Schools

D. Berzina, WP 4 leader

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The objective of the activities under WP 4 is to facilitate the development and transfer of knowledge in photonics at national and international levels, to raise the publicity and visibility of FOTONIKA-LV researchers' community and to become a visible and recognized partner in the European Research Area. The WP has six tasks:

- presentation of the FOTONIKA-LV research community's scientific results at high level international conferences;
- organisation of the 1st International Conference "Photonics Technologies, Riga 2012" that also included an exhibition for "high-tech" SMEs and a research training course;
- organisation of the 1st International Conference "Bio-Photonics, Riga 2013" that also included an exhibition for "high-tech" SMEs and a research training course;
- organisation of the 1st International Conference and research training course "Nocturnal Riga 2014";
- organisation of the 3rd International Conference on Integrative Approaches Towards Sustainability "KNOWLEDGE";
- organisation of strategy planning and technology foresight workshops.

The planned conferences were successfully implemented as indicated below:

- "KNOWLEDGE" took place June 27-30, 2012 in Jurmala with 61 participants from 15 countries, 14 plenary lectures *(including 3 Skype presentations*), 16 presentations in parallel sessions, 25 oral/poster presentations from young researchers, and 2 round-table discussions.
- "Photonics Technologies, Riga 2012" *(including a complimentary brokerage event on FP7 Photonics topics)* took place August 23-28, 2012 in Riga at the University of Latvia: 97 participants from 14 countries, 12 plenary lectures, 22 presentations in parallel sessions *(including young researchers)*, 19 poster presentations by young researchers, 1 roundtable discussion. The Research Training Course with 11 lectures was attended by 40 young researchers, and the Exhibition had 7 SME participants.
- "Bio-Photonics, Riga 2013" took place August 26-31, 2013 in Riga at the University of Latvia with 95 participants from 17 countries. There were 18 plenary lectures, 22 presentations by young researchers, 29 poster presentations by young researchers. The Research Training Course had 18 lectures attended by 36 young researchers and about 15 other conference participants. Ten SMEs participated in the Exhibition.
- "Nocturnal Riga 2014" that included the bonus event International Day of Photonics took place October 16-22, 2014 in Riga at the University of Latvia with 63 participants from 15 countries, 17 plenary lectures, and 22 poster presentations by young researchers. There were 32 attendees of the Research Training Course.

The FOTONIKA-LV research community's scientific findings have been presented at over 25 high level international events both in the EU and beyond *(Armenia, Belarus, USA, Japan, South Korea, Ukraine, Taiwan, Russia)* by Invited lectures, oral and poster reports, as well as by establishing new research contacts for future collaboration.

Results of WP 5 – Dissemination, Promotion, Contribution to Innovation – Public Access Riga Photonics Centre

A. Atvars, WP 5 leader

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In 2014 multiple dissemination activities of WP5 (*Dissemination, promotion, contribution to innovation – Public access Riga Photonics Centre)* for the project FOTONIKA-LV [1] took place:

1) The establishment of a Facebook page for Riga Photonics Center – *https://www.facebook.com/fotonikalv/*;
2) The establishment of LinkedIn presence for FOTONIKA-LV – *https://www.linkedin.com/company/fotonika-lv*;
3) Photonics prize for the best student presentation, 72nd Conference of University of Latvia, section on the project FOTONIKA-LV, 07.02.2014;
4) Press releases have been issued for most events held by FOTONIKA-LV at the Riga Photonics Center;
5) Seminar „Protection of Intellectual property". About 15 participants heard about patents and industrial models. Lectures were conducted by experts of Patent Office of the Republic of Latvia – Dace Liberte, Asja Dislere and Evita Lande. 15-16.04.2014;
6) Regular video presentations in the window screen of Riga Photonics Center;
7) Seminar on Photonics commercialization cases, 15.05.2014;
8) FOTONIKA-LV was co-organizer with the Space Technology Cluster of Latvia and the firm Space Technology and Science Group, Oy, of ICCST 2014, *"the International Conference on Collaboration in Space Technologies"*, held on June 5-6, June 2014 at the Kipsala Exhibition Center, Riga, Latvia. The conference opened by former President of Latvia Vaira Vike Freiberga, had over 100 participants most from Latvia. There were presenters from several African countries and the African Union Commission, Latvia, Nordic and Central European countries. The purpose of the conference was aimed at opening a dialogue between Africa and our region to apply the extensive space research and space technology capabilities in our region to address critical problems in Africa including environment, security, food, water and other concerns. An exhibit presented the competencies of Latvian companies and research groups in space science and technologies with potential application in Africa. The conference web page with presentation videos: *http://www.iccst.eu*.
9) Report of the FOTONIKA-LV general meeting held 19.06.2014. publicized in a popular science magazine [2] to give publicity to FOTONIKA-LV;
10) *www.fotonika-lv.eu* was covered with additional content, for example, Innovations section included references and descriptions on Horizon 2020 calls for SME Instrument;

Fig.1. Crowd of students in the Riga Photonics Center near the demonstration of the growth of snowflakes, 26.09.2014.

11) Youtube channel of FOTONIKA-LV established: *https://www.youtube.com/channel/UCevoPT9W4YjpHlLSeM_D71Q/videos*;
12) Riga Photonics Center participated with several presentations in the Researchers Night, 26.09.2015, *see Fig.1*;
13) More than 20 colloquiums held where researchers and SMEs local and foreign presented their research developments, *see Table 1*;
14) Special colloquium organized to mark The day of Photonics, 21.10.2014;
15) FOTONIKA-LV was active in public policy forums relating to research and innovation policy with presentations to members of the Saeima *(parliament)*, ministerial officials, various groups and organizations involved with research policy with a particular emphasis on the role of photonics in the smart specialization strategy of Latvia. Letters have also been prepared to the Prime Minister of Latvia and counterparts in Estonia and Lithuania regarding photonics, smart specialization and the priority importance of innovation [3].

Table 1. Colloquiums organized by FOTONIKA-LV

No.	Date of Colloquia	Presenter and the title
45	17.01.2014.	Dr. Amara Graps, "New project initiatives"
46	28.01.2014.	Tomas Mosteikis and Arturas Belickas, Altechna LTD, "Services and capabilities of Altechna, serving photonics research and industry throughout the Baltic region"
47	31.01.2014.	Mats Kjaer, "Stimulating innovation in Latvia: The IDEON model from Lund, Sweden".
48	05.02.2014.	Dr. Amara Graps un Pauls Irbiņš, "How to raise interest and to convince students to study Natural sciences, engineering and mathematics"
49	28.02.2014.	A. Ubelis. Welcome address, "Importance of foresight for the development of Association FOTONIKA-LV and corporate tasks of FP7 FOTONIKA-LV", Vidvuds Beldavs, "Foresight process and smart specialization", Sandra Smalina, "Foresight process methodology"
50	11.04.2014.	Mikelis Svilans, "Research perspectives for silicon microphotonics in Latvia"
51	16.04.2014.	Dr. Arvind Kumar Saxena, Physical Research Laboratory Space & Atmospheric Science Division, Ahmedabad, Gujrat-India, "Study of cluster ions by mass spectrometry and optical spectroscopy"
52	25.04.201.4	Lecture by Prof. Eimuntas Paršeļiunas, (*http://www.gkk.ap.vgtu.lt/media/cv/10033_EN.pdf*), Vilnius Gedimina university Department of Geodesy and Cadastre
53	25.04.2014.	Prof. Dainis Draviņš (Lund Observatory), "Astronomical Imaging a Thousand Times Sharper than Hubble: Optical Interferometry with the Cherenkov Telescope Array"
54	04.06.2014.	M. Banaszkiewicz, "Space Technologies in Poland"
55	18.06.2014	Dr. Janis Kletnieks, "About Astronomy and Geodesy in 19th century"
56	09.07.2014.	Dr. Marco Delbo, Lab. Cassiopee, UMR UNS-CNRS-OCA, Observatoire de la Cote d'Azur, "Cracking up asteroids with Sun light"

57	11.07.2014.	Dr. Georg Kirchner (Space Research Institute, Austria), "Satellite Laser Ranging at Graz – present status / future plans: - performance characteristics of SLR Graz - kHz SLR - Space debris, Multi-Static Ranging etc. - Satellite Spin determinations" Dr. Ludwig Grunwaldt, Germany, "Activities of GFZ Potsdam".
58	30.07.2014.	Dr. Amara Graps, FOTONIKA-LV, Dr. Normumds Jakobsons, Ventspils Radioastronomy Center, PhD student Karina Skirmante, „Potential of Ventspils Radioastronomy facilities for research training"
59	08.08.2014.	J. Upatnieks. "Presentation on the personal history of the development of holography. Discussion"
60	08.08.2014.	Dr. P. S. Smertenko, Dr. V. V. Naumov, Institute for Fundamental Problems of High Tehnology, Kyiv, Ukraine, "Eventual Proposal to HORIZON 2020 calls: "Skin Measurement Device for Health Care, Cosmetology and Dermatology""
61	15.08.2014.	P.Smertenko, V.Beldavs, "Technology commercialization and innovation ecosystem"
62	22.10.2014.	Contributors: Dr. Jorge del Pino, Dr.Ludwig Grunwald, Dr. Bülent Bayram, Dr. Mkhailo Medvedskyy, Dr. Maris Abele, Dr. Janis Balodis Dr. Ansis Zariņš, Dr. Augusts Rubans, Janis Vjaters, Elina Rutkovska, Andris Treijs, "Advances satellite ranging technologies. Discussion"
63	24.10.2014.	Dr. A. Saxena, "Research of molecular clusters"
64	11.11.2014.	Dr. Aden Hodzic, Scientific Industrial Laison Officer , Central European Researsh Infrastructure, Consortium (CERIC) with Headqurter at Synchrotron Elettra, (Italy), "The Project 'CERIC-ERIC'" Scientific Applications and Technology Transfer"
65	19.11.2014.	A. Atvars. "Report on the conference "The Next Giant Leap: Leveraging Lunar Assets for sustainable pathways to Space", Hawaii, USA,9.-13.11.2014", *http://2014giantleap.aerospacehawaii.info/*; V. Beldavs, "International Lunar Decade"
66	21.11.2014.	Kalvis Salmiņš, Jorge Del Pino, "Report on the conference "19th International Workshop on Laser Ranging: Remembering the past and Planning for Future"".
67	28.11.2014.	Dr. Gunars Silabriedis and others, "About scientific projects of Ministry of Defence of Latvia, projects of NATO and USA NAVY"
68	12.12.2014.	Prof. Dr. Kerim Allahverdi, TUBITAK (Turkish Scientific and Technological Research Council), MRC (Marmara Research Centre), Leader of the Lasers and Laser Technologies Lab., "Space Technologies Research Institute of TUBITAK"
69	30.12.2014.	Prof. Jumisree Sarmah Pathak, Indian Institute of Teacher Education, Grandhinagar, Gujarat, India, „Spectroscopic studies of spices, nanomaterials and clusters"

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[2] A. Atvars. The General meeting of FOTONIKA-LV. Starry Sky (*Zvaignota Debess*), Autumn 2014, p. 63-66. (in Latvian)

[3] V. Beldavs. Letter to Prime Minister Laimdota Straujuma and her counterparts in Estonia and Lithuania as well as other key figures in research and innovation policy – *https://fotonikalv.files.wordpress.com/2014/12/research-and-innovation-a_pan-baltic-priority-2014-10-31.pdf*.

Development and Application of Novel Photonic Materials

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Development of nanotechnology stimulated enhanced fabrication of nanomaterials with tailored structural, electrical and optical properties [1, 2]. Among them, photonic nanomaterials *(materials with advance photoluminescence, absorbance, refractive index, etc.)* are the most promising as they are used for different applications such as photocatalytic cells, solar cells, transparent coatings, protective coatings, sensors and biosensors [3].

The actual problems in photonic nanostructures are increasing of surface-to-volume aspect ratio and enhancing a photonic signal [2]. Using specific templates *(Fig. 1)*, like organic nanofibers, it makes possible to achieve high efficiency of photonic response. The high surface-to-volume aspect ratio makes photonic materials attractive for applications in biosensors and gas sensors, among other applications [3].

In the present work we demonstrate development of new photonic nanomaterials by nanotechnology methods, characterization of their optical and structural properties and further strategy for applications.

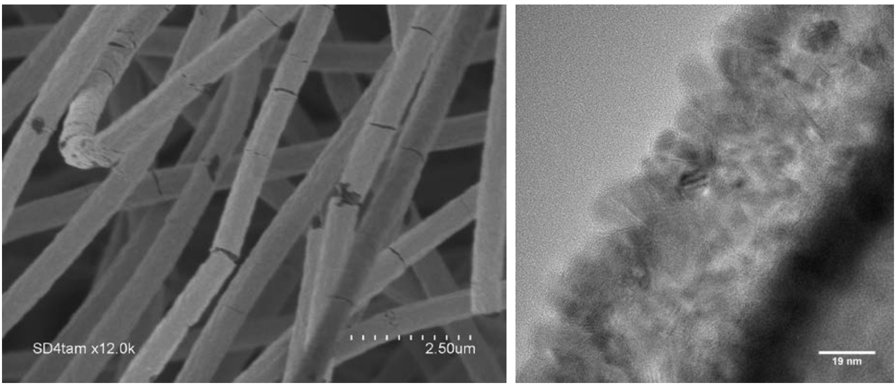

Fig.1. SEM (on the left) and TEM (on the right) images of 20 nm ZnO coated over 300 nm organic nanofiber

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New Calibration for the Riga SLR Station

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During the 19th International Laser Ranging Workshop (*Annapolis, MD USA October 27-31/2014)* it was agreed that a development focus for the entire ILRS Network in the next years should be on improving quality control and reducing systematic errors and biases at the SLR stations.

In particular, the reduction of the so-called distance "range bias" error to a stable value as close to 0 mm as possible is a very important goal. This bias is directly affected by the hardware, software and methodology used to calibrate and reduce the SLR observations done by each station.

We report here the current situation of the upgrades and modifications done to the Riga 1884 SLR hardware, software and operational organization, and the current status of the experimental determination of the new 'fundamental calibration' constants that will be used on the data reduction.

As reported previously on the 1st Nocturnal Conference [1] we have already achieved a reduction both on the internal sigma error of each individual calibration and in the medium-term (few months) calibration series dispersion.

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Manifestation of Multiple Dressed States in Hyperfine Levels of Na: the Death of Dark and some Bright Components in Autler-Townes Spectra

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We conducted theoretical studies of the formation of laser induced adiabatic states in a multilevel two-state quantum system with Hyper Fine (HF) splitting which is essential in observing laser-matter interaction phenomena under experimental conditions. Our numerical data for a typical optical Autler-Townes (AT) [1] experiment in a three-level ladder scheme (a weak probe field in the first excitation step and a strong coupling field in the second step) shows essential diminishing of AT spectra components due to newly created dark states in the system. For a specific excitation ladder scheme $3S_{1/2}(F'' = 2, 1) \rightarrow 3P_{3/2} \rightarrow 4D_{5/2}$ in sodium we also demonstrate the death of some bright AT which was a novel unexpected result. Our theoretical treat revealed a number of nontrivial moments in the manifestation of HF adiabatic states depending on the coupling laser intensity:

(i) At intermediate coupling field Rabi frequencies the HF operator is comparable to the coupling one, which results in noticeable mixing between different orthogonal adiabatic wave functions, in particular, between individual sets of bright and dark states. The mixing populates dressed states which are decoupled from the excitation scheme, e.g. "gray" states, and gives rise to a number of extra AT multiplets.

(ii) At large coupling field strengths, the HF atomic operator is treated perturbatively; the number of bright and dark states and their explicit representations is found from the classical Morris-Shore transformation [2]. Multiple dark states are created from the "grey" ones, while some "bright" AT components gradually die with the increase of coupling laser power.

From a practical point of view our most important finding consists in that probing from the ground state HF sublevel F′′=2 or F′′=1 results in the appearance of quite different AT components. The multiplets originating from the different ground state sublevels are complementary to each other, i.e. at high coupling field powers the probe laser populates different orthogonal configurations of adiabatic states depending on the HF-channel (F′′=2 or =1). In terms of applications this opens, for instance, nontrivial perspectives to form a two-component bichromatic polariton: a single strong control laser can drive the independent propagation of two uncoupled quantum probe fields.

This works was carried out within 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 Research Councils are acknowledged.

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Measuring Rubidium Optical Transitions with a Femtosecond Frequency Comb

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Optical frequency standards have surpassed microwave frequency standards thanks to the femtosecond optical frequency comb that allows counting optical frequencies. Within the FOTONIKA-LV Project we have acquired a modern commercial femtosecond optical frequency comb (*Menlo Systems*) that can transfer frequency stability from microwave region to optical region with 14 digits of precision.

Our goal is to compare frequency stability of optical transitions in Rb atomic vapor against a commercial microwave rubidium clock (Ч1-69). We calibrate the Rb clock against GPS satellite time. This allows 11 digits of precision to be achieved but several hours are necessary to reach this level.

Counting optical frequencies from an ultrastable two-mirror Fabry-Perot (FP) interferometer allows achieving 14 digits of precision in one second. But such FP interferometers possess long-term drift from ageing and temperature fluctuation, and, usually, are referenced against optical transitions in atoms or molecules. One of suitable candidates for referencing is Rb vapor.

We have set up an external cavity diode laser at 780 nm that excites D_2 line in Rb and observe saturation spectroscopy peaks from ^{85}Rb and ^{87}Rb isotopic hyperfine transitions. The rubidium optical cell is placed inside a magnetic shield to minimize Zeeman shift. Next step is to stabilize the laser to Rb saturation transitions using frequency modulation locking and measure precisely the optical frequencies against the frequency comb referenced on microwave Rb clock.

Optical reference in Rb atoms will be used to characterize the stability of a specially built tellurium molecular reference at 480 nm that was prepared for laser spectroscopy of antimatter atoms positronium at ETH Zurich.

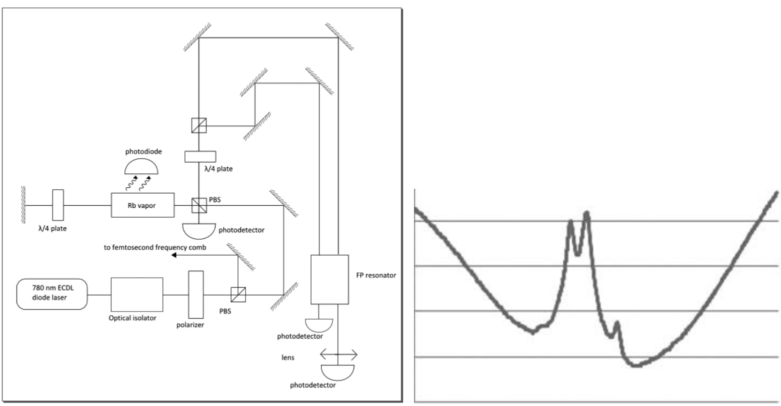

Fig.1. Optical set-up and example of saturation signal in rubidium.

The International Lunar Decade: A Giant Leap Forward in Understanding the Moon and Opportunities for its Development

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In 1957 at the dawn of the space age the United Nations launched the International Geophysical Year which had a profound impact on collaboration among scientists around the globe. Its legacy includes several major scientific organizations as well as the beginnings of collaboration among nations that see themselves as competitors on Earth. The Soviet Union and the United States made many attempts at collaboration in space while building weapons systems to destroy each other. Space technologies have become the infrastructure for the ubiquitous smart phone with global telecommunications, navigation, weather forecasting, environmental monitoring, and hundreds of other applications. In 2015, the International Year of Light, several conferences will be held exploring the idea of an International Lunar Decade [1]. An informal group, the International Lunar Decade Planning Group (ILDPG) has been form to plan the launch of the International Lunar Decade in 2017, the 60th Anniversary of the International Geophysical Year. This report will cover the progress of the ILDPG covering conferences planned, international organizations involved and key publications. The activities of the ILDPG can be followed at *http://2014giantleap.aerospacehawaii.info/* as well as at *http://internationallunardecade.wordpress.com*.

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Transfer of Emerging Technologies by LU Association FOTONIKA-LV

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Any research institution's capacity for doing research is bounded by the technologies that it has. Availability of new technologies always means wider capability to conduct research at a higher technologic level. To solve mechanic problems the Association obtained a universal lathe *(capable <72cm)* and grinding *(<130cm)* benches, drill stand, a Pneumo bandsaw *(<50cm)* and a variety of hand tools, including an argon TIG welder for stainless steel and Al. Additionally an A4 sized DIY bench was erected for 3-D CNC grinding, laser-cutting and 3-D printing, thus there are no more limitations to the production of vacuum vessels or the fabrication of sophisticated parts such as sample holders or experimental devices.

For more complex problems the Physics Department of Gothenburg University jointly with the team of researchers from the Association used FP7-REGPOT-CT-2011-285912 secondment resources and created a *"critical mass"* of human resources which resulted in adaptation of decommissioned equipment to build a new type of negative ion beam source and facility including the addition of a time of flight spectrometer to enable analysis of the interaction of ions by a scanning laser beam. This became the first mobile version ion beam device that is transportable to the locations where specialized powerful light sources, such as synchrotron radiation, can then be explored to understand the Rydberg belt linked processes in atomic shells. The device is called GRIBA [1], The apparatus specifically can be used for electron affinity measurements of small carbon containing molecules which is on the research agenda for astrophysics and chemistry in the near term future .

Currently on the list is scanning laser with powerful Nd-Yag exciter and OPO box, now in process of tuning. Until this equipment becomes operational we were missing the technique despite the need.

The dust-free cleanroom that was built by very careful engineering is giving hope that after some refinement it will provide purity better than ISO-5 and hopefully as good as ISO-3. The vacuum sputtering device with 70cm chamber, two ion guns, filament source, RF ICP source and new age (phase controlled) quartz layer thickness control, will be positioned there. Such a device would enable the production of glass to glass type interference layers, thereby building our capacity to make everything in optics that is needed for research. There is also a small 20cm filament type vacuum coater that would enable coating metallic layers *(i.e. contacts patches)* on more robust parts.

Next step is 130cm large astronomical mirror metallization chamber, that soon will be delivered to FOTONIKA-LV, as well as mirror grinding, polishing, and test equipment.

Last but no least there are new electronics designs for more powerful and stable ICP plasma sources feed with radiofrequencies (ca 50...300 W), and two designs for plasma torch feeder CC/CV-SMPS with PFC, as well as self-shutting 1 MHz plasma igniter.

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Visualizing Magneto-Optical Effects by Bright and Dark Atoms

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Actions of optical and magnetic fields on atoms or molecules are known as magneto-optical effects. Prepared by optical pumping spin-polarized alkali vapors have, in general, a reduced optical absorption coefficient for the radiation that has prepared the sample. The atoms are said to be in a dark state, so called because the reduced absorption is mated to reduced fluorescence intensity. A static magnetic field oriented along the spin polarization will stabilize the dark state, and hence the reduced fluorescence, while transverse static fields or a resonant oscillating magnetic field (with oscillation frequency equal to the Larmor frequency of the applied field) will depolarize the sample and lead to an increased fluorescence. We have developed a magnetic field imaging system based on these properties [1]. A 1.2 mm thick sheet of laser light tuned to the 4-3 component of the D1 transition prepares a sheet of spin-oriented atoms in a cubic Cs vapor cell with 8 mbar of Ar and 45 mbar of Ne buffer gas. The cell is exposed to an inhomogeneous magnetic field. A 16 bit CCD camera records emitted fluorescence. The cell is further irradiated by a oscillating multi-component *rf* field. Depolarizing, i.e., fluorescence-inducing magnetic resonances occur wherever the Larmor frequency corresponding to the modulus of the local magnetic field is resonant with a component of the radiofrequency comb.

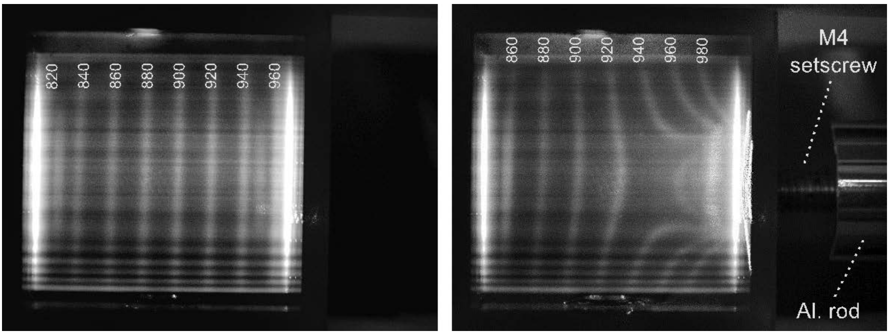

Fig.1. Iso-modulus lines in a region with a homogeneous magnetic field gradient (left) and deformation of the lines by an M4-setscrew (right).

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Secondment visit in Moletai Observatory, Institute of Theoretical Physics and Astronomy, Vilnius University

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The visit to the Moletai Astronomical Observatory from October 3 till November 8, 2014 included the following research tasks:

- The review of new observation processing software for asteroids. SkySift [1] is a real-time image processing software which has been designed to detect and identify moving objects in astronomical images.
- Schmidt digitized astrophoto plates data was processed and the paper "Method for evaluating the astrometric and photometric characteristics of commercial scanners in their application for the scientific purpose" was prepared.
- Upgrade of Baldone Schmidt telescope Earth rotate compensation mechanism. Quartz oscillator was replaced with stepper motor.
- Methodology of evaluation of the interstellar absorption to determine real distances of carbon stars using low resolution spectra of Baldone Schmidt telescope was created.

Fig.1. Moletai Astronomical observatory.

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Modernization of SLR Station Riga and Future Prospects

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This paper discuss overall SLR system Riga modernization plan and the first completed steps. The first refurbished SLR subsystems were timing and calibration. Old rubidium time and frequency sources were replaced with GPS steered rubidium clocks and their performance evaluated [1]. New fiberoptic line was installed to transfer 10MHz reference frequency from laboratory building to the SLR telescope. Calibration system was redesigned and simplified: multi-mode fiberoptic cable in the internal calibration path was replaced by single mode fiberoptic cable resulting in reduced calibration value dispersion. Internal calibration path was decoupled from the laser beam entry in telescope simplifying alignment and increasing calibration stability. We assess future research directions including space debris and dysfunctional satellite tracking.

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Results on Secondment Visits to Belarus and Crimea

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Crimean Astrophysical Observatory /1/ besides others is known for its optical production facility, making all telescope lenses and mirrors that astronomers needs with a reputation that their optical quality is higher than the Russian LOMO and many Western producers. There were problem with vacuum sputtering machine with a Soviet computer from the 1980s that had hopelessly crashed. The aim of the visit was assistance to shift away from the old computer to a modern-day Arduino ARM and exchange of knowledge in mirror grinding and metallization. Good contacts were established and plans developed for future collaboration. Unfortunately, due the war all collaboration has been cancelled. The unit has several tens of analog outputs and the same amount of servosignal digital+analog inputs. Thus we used an Arduino Mega chipset and soldered cabling to the machine, while their technologist, who knew C++ language even better than us, wrote appropriate software. Today they are still happy with the result and the machine is going into exploitation. An article was prepared about the accomplishments for a Russian journal, but political changes cancelled publishing. As a reward for our work and assistance they explained the nuances of the machinery, chemistry, methods and technology they use for mirror cutting, grinding, polishing, as well as techniques for washing away the old layers, aluminisation and explained the plusses and minuses of different protective layer covering techniques. We had a hands-on training session where we were able to produce layers of sufficiently high quality in contrast to our experience when we tried it beforehand at home. This visit enabled us to understand many our previous mistakes, thus the production of large astronomical mirrors at the association FOTONIKA-LV for White-Light project, Zenith Telescope, Mobile SLR Telescope seems to have become much more realistic.

Byelorussian ITMO institute is outstanding in plasma heating processes, including the microwave (MW) plasma, which was new experience for us. They demonstrated that with increasing frequency plasma particle temperature will increase so the MW plasma is the best candidate for calcium *(hydroxyapatite)* nanoparticle melting torch buildup. They demonstrated know-how and circuitry how to organize plasma feeders to get 2,4 GHz, 400 MHz, 1 MHz plasmas and in the process we developed the competence to attempt to replicate their MW plasma torch adapted for our task, with worldwide used electronics. his creates the possibility for innovation in 3D CNC printing technology.

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Overview of Impact of the FOTONIKA-LV Project on Institute of Astronomy

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The large-scale project FOTONIKA-LV has enabled the development of the Institute for nearly four years building contacts with collaborating institutions in the EU, Ukraine and worldwide as well as planning for modernization of the research equipment of the Institute.

Highlights of some activities:

- The principal investigator I. Eglitis had the opportunity to conduct 3 person months of research at the Moletai Astronomical Observatory – Institute of Theoretical Physics and Astronomy (ITFA) in Lithuania.
- K. Salmins, Director of the Geodynamics Observatory worked for 2.5 person months at the GFZ German Research Centre for Geosciences in Potsdam.
- A methodology was developed to determine distances of carbon stars through interstellar absorption of low resolution spectra using the Baldone Schmidt telescope in cooperation with Professor V. Straižys, ITFA;
- Observation processing software "Astrometrica" and "SkySift" were reviewed to detect asteroids through comparison of observations recorded in digitized images of astrophoto plates in the Baldone astronomical archives in cooperation with Dr. K. Černis, ITFA.
- Development Schmidt digitized astrophoto plates data software was processed and the paper was prepared "Method for evaluating the astrometric and photometric characteristics of commercial scanners in their application for the scientific purpose".
- Consultations with Dr. R. Janulis (ITFA) about upgrade of Baldone Schmidt telescope Earth rotate compensation mechanism.
- Consultations with Dr. E. L. Grunwaldts (GFZ) about upgrade and modernization of the SLR system at Riga, including hardware and software in anticipation of future experiments with space based transponders.
- Institute researchers have had the opportunity to take part in 9 foreign (in UK, Czech Republic, Finland, USA, Japan, Belgium) and three International conferences raised by Association FOTONIKA-LV. Oral and poster reports were presented about research underway at the Institute of Astronomy, University of Latvia.

During the project the following foreign investigators were recruited to solve problems that included: digitization of over 20,000 astrophoto plates from nearly 40 years of observation by the Baldone Schmidt telescope; upgrades to hardware and software at Baldone Astrophysical and Riga Geodynamical observatories; and to write project applications to EU Structure funds and other funding sources:

- Dr. Justas Zdanavičius *(recruited from ITFA)* 13 person months,
- Dr. Vygandas Laugalys *(recruited from ITFA)* 13 person months,
- Dr. Jorge Roberto del Pino Boytel *(recruited from Centro Nacional de Investigaciones Sismológicas, Cuba)* 21 person months and
- Dr. Amara Linna Graps *(recruited from Institute of Planetary Science, USA*) 17 person months.

Approved projects:

- 2015-2017 Horizon 2020 INFRAIA-1-2014 "Europlanet-RI-2020" 10 mEUR *(IA as subcontractor ~40 kEUR)*
- VPP *(State Research Program)* "Multifunctional materials and composite, photonics and nanotechnology" (IMIS2), *(Coordinator A.Sternbergs, LU CFI)* subproject Nr.1. "Photonics and materials for photonics"2014-2017 *(IA as subcontractor ~17 kEUR)*

Submitted projects:

- 2014 P. I. "An Asteroid and Comet Database from the Baldone Observatory",
- NASA Planetary Data Analysis and Archiving Program 2014 (PDART). September 17, 2014.
- Co-I: Horizon 2020 Widespread 1-2014: Teaming: "Photonics Balticum", September 17, 2014.
- Horizon 2020 Call: H2020-WIDESPREAD-2014-2 "Space-LV", October 16, 2014
- Horizon 2020 Call: H2020-WIDESPREAD-2014-2 "Bounce", October 16, 2014

Overview of Impact of the FOTONIKA-LV Project on the Institute of Geodesy and Geoinformatics

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Currently LU-GGI focuses on research in satellite geodesy and geoinformatics. During the FOTONIKA-LV project period the Institute has participated in three EU Regional Development Fund projects, two of them are still in progress – one concerning design of a new multi-purpose optical tracking system with SLR capability, the other – utilizing levelling, gravimetric and vertical deflection measurements to calculate local geoid model parameters. The digital zenith camera, prototype of which was designed within the previous project, will be completed and used for vertical deflection measurements.

Additionally, the Institute also carried out studies of vertical and horizontal motion of the Earth's crust in Latvia using analysis of GNSS observations at the LatPos and EUPOS-RIGA permanent station networks. GGI also participates in a number of international cooperation projects.

FOTONIKA-LV has made possible a number of research visits of foreign specialists to GGI. Funding has been provided for participation in international conferences for many Institute researchers, in particular for new scientists and doctorates. FOTONIKA-LV has provided funding for substantial purchases, necessary to improve the technical capacity of GGI and to provide critical components for scientific instruments that have been designed here. Cooperation with other partners of FOTONIKA-LV, established during project, will provide basis for future coordination of research efforts.

Overview of Impact of the FOTONIKA-LV Project on the Laboratory of Quantum Optics, Institute of Atomic Physics and Spectroscopy

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The Quantum Optics group was established in 2013 at the Institute of Atomic Physics of Spectroscopy in Latvia. The direction of present research is towards comparing and improving optical and microwave frequency standards. Stable frequency references are very important for increasing speed of telecommunications, improving satellite navigation, geodesy and precision of fundamental constants in physics.

We have set up a modern optical femtosecond frequency comb *(Menlo Systems GMBH)* allowing the counting of optical frequencies and linking of optical frequencies with microwave frequency standards such as rubidium clock and GPS time clock.

We have set up semiconductor diode lasers at 780 and 980 nm, stabilized on Fabry-Pérot (FP) resonators, rubidium (Rb) saturation spectroscopy set-up and tellurium (Te_2) molecular spectrum reference. Tellurium reference is necessary for positronium laser spectroscopy experiment at ETH Zurich. A class 6 cleanroom flowbox was installed that is essential for assembling ultrastable FP resonators.

Fig.1. Left: cleanroom box and femtosecond optical comb laser on the 2nd floor.
Right: group members in the newly renovated diode laser spectroscopy laboratory on the 5th floor.

Overview of Impact of the FOTONIKA-LV Project on the Laboratory of Atomic Physics, Atmospheric Physics and Photochemistry, Institute of Atomic Physics and Spectroscopy

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The successful funding of the project FOTONIKA-LV *(FP7-REGPOT-CT-2011-285912)* confirmed the excellence of the Association FOTONIKA-LV formed by three research institutes *(The Institute of Atomic Physics and Spectroscopy, the Institute of Astronomy and the Institute of Geodesy and Geoinformatics)* at the University of Latvia. The success rate for relevant FP7 call was 7% and each of the institutes and their laboratories, observatories and departments contributed with their excellence in science and applied research nurtured for many years. Combined they were able to demonstrate success in working together in association as a multidisciplinary teams. That resulted in evaluation mark of 15 from 15 resulting in the financing of the FP7-REGPOT-CT-2011-285912 project.

The Laboratory of Atomic Physics, Atmospheric Physics and Photochemistry emerged from the team of researchers dedicated to the research on reactions of metastable atoms of selenium, tellurium and sulphur in the conditions of high temperature flash photolysis in the early 1970s. In addition to strong interest in fundamental research there was a direct applied part related to photochemical lasers and lasers on semi-limited transitions. Therefore besides mentioned elements of the oxygen subgroup metastable atoms of lead, tin and copper were also among targeted subjects for research.

On 22 September 1988 the Vienna Convention for the protection of the Ozone Layer entered into force. The decision was taken to move towards contribution to atmosphere physics and photochemistry based on the researchers' expertise in dealing with atoms and molecules of the oxygen subgroup and relevant skills in spectroscopy, flash photolysis and light source development. Immediately following the fall of the Iron Curtain in 1990 collaboration contacts were established with Prof. Sune Svanberg in Lund University to work together on fundamental constants of mentioned atoms. A few years later in 1993-1995 close cooperation started with the Institute of Environmental Physics at the Bremen University and the first joint laboratory experiments were performed on flash photolysis of iodine & ozone mixture to measure rate constants of chemical reactions present in ozone layer and fundamental constants of iodine oxygen dimmers. Basic step forwards to become visible in the European landscape was participation in EUREKA 1489 EUROTRAC 1&2 project (1996-2003) on *"Transport and Transformation of Environmentally Relevant Trace Constitutents in the Trophosphere Over Europe"* and work together with atmosphere researchers community in the FP6 project grant no. GOCE CT-2004-2009-505337 *"Atmosphere Composition Change: The European Network of Excellence" (43 research units from 21 European countries represented).*

Listed above research activities and main projects provided strong evidence of excellence contributing to the success of the *(FP7-REGPOT-CT-2011-285912)* project proposal which unlocked and strengthened the research potential of the laboratory and many research efforts of the laboratory team are reported in the Abstract books of the University's Annual conferences as well as in various publications.

The overall impact of the FOTONIKA-LV (*FP7-REGPOT-CT-2011-285912)* project on the performance of the laboratory is impressive. The number of staff increased from 4-5 researchers to more than 20. The laboratory now is the main contributor to the Association FOTONIKA-LV HORIZON 2020 task force, but during the last 3 years the laboratory succeeded to win and is implementing 3 FP7 projects granting some sustainability:

- Coordinating "Nocturnal Atmosphere", FP7-PEOPLE-2011-IRSES, G. a. 294949 *(01.02.2013-31.01.2017)* , the title *"Secondary photochemical reactions and technologies for active remote sensing of nocturnal atmosphere*";
- Coordinating "BIOSENSORS-AGRICULT" FP7-PEOPLES-IRSES *Nr.316177 (01.09.2013-31.08.2016).* Title: *"Development of Nanotechnology Based Biosensors for Agriculture"*;
- Participant in the "Next Step" FP7-PEOPLE-2013-IRSES, 612691 (*01.12.2013-30.11. 2017*), the title *"An international network on new strategies for processing calcium phosphates"*;
- Informally associated member to "FP7 PEOPLE-IRSES-GA-2011-294959 – International Foresight Academy" (*2012-2015*).

The FOTONIKA-LV (*FP7-REGPOT-CT-2011-285912*) project provided opportunities to upgrade research facilities:

- The main outcome was building the Gothenburg-Riga Ion Beam Apparatus GRIBAM. The apparatus was built via joint efforts of colleagues of our laboratory and colleagues in Gothenburg University using secondment visit exchanges. This is the first mobile ion beam instrument in the world. See the picture below:

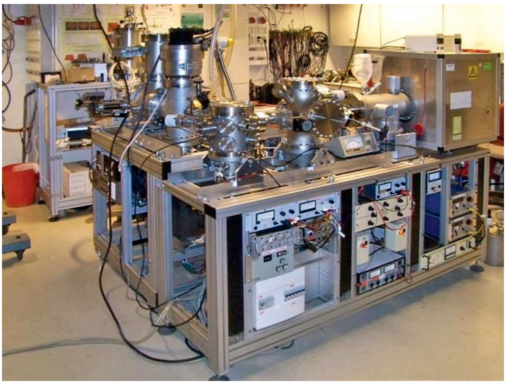

Fig.1. Gothenburg-Riga Ion Beam Apparatus GRIBAM

- Another impressive success dedicated to industry need – the design of a universal vacuum sputtering device to satisfy diversity of sophisticated experimental needs and industrial demands positioned in a small sized package and therefore not costly clean room chamber;
- Further progress was made in the field of atmosphere research and relevant infrastructure development – the "ROFLEX" instrument for the field measurement of iodine concentrations in atmosphere has been upgraded with a new inductively coupled plasma generator, modified iodine atomic spectra sources and the first efforts to add bromine atomic spectra sources.
- Considering future developments is worth to add, that the laboratory has good balance between generations of scientists in the laboratory.

Controlling the Interaction of a Few Cold Rb Rydberg Atoms by Radio-Frequency Assisted Förster Resonances

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We studied the radio-frequency-induced Förster resonances in cold Rb Rydberg atoms in a magneto-optical trap[1]. 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. The resonant condition can be realized by tuning the levels with weak electric field.

In our experiments we excited cold Rb atoms to the initial 37P state. At 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 are detected by means of selective field ionization technique. If we admix a radio-frequency electric field to the dc field, it can induce additional Förster resonances. The rf photons compensate for the energy defect of the Förster resonance and induce additional resonances, which correspond to the induced absorption or emission of rf photons. If the rf amplitude is large enough, it can even induce multiphoton transitions of high orders.

Not all levels can be used to realize Förster resonances by tuning the dc electric field. An example of such „inaccessible" Forster resonance is the 39P+39P→39S+40S, for which the dc field alone increases the energy detuning. However, our experience with the Förster resonance for the 37P state suggests that the rf-field can induce transitions between collective states, so the Förster resonance occurs irrespective of the possibility to tune it by the dc field alone. The dc field, however, should be applied to increase its efficiency. We have obtained a Förster resonance at 39P+39P→39S+40S with rf-field at multiple frequencies. The position of the rf-assisted Förster resonance depends on the rf-frequency, while its width and height depend on the number of atoms N.

These resonances correspond to single- and multiphoton rf-transitions between many-body collective states of a Rydberg quasi-molecule or to intersections of the Floquet sidebands of Rydberg levels appearing in the rf-field. We have shown that they can be induced both for the "accessible" Forster resonances, which are tuned by the dc field, and for those which cannot be tuned and are "inaccessible". The van der Waals interaction of almost arbitrary high Rydberg states can thus be efficiently transformed to resonant dipole-dipole interaction using the rf-field with frequencies below 1 GHz. This strongly enhances the interaction strength and distance and can give rise to much stronger dipole blockade effect, which is used in numerous applications of Rydberg atoms.

This work was supported by RFBR (*Grants N. 13-02-00283&14-02-00680*), the Russian Academy of Sciences the EU FP7 IRSES Project "COLIMA". and the Russian Quantum Center.

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TRIZ Tools for Inventive Problem Solving

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TRIZ is a theory for inventive problem solving (*from Russian acronym – Теория Решения Изобретательских Задач)* that helps to solve various technical problems (and also non-technical problems) with a high quality and can lead to patentable developments. It was designed by G. S. Altshuller and his team in Soviet Union. The first publication on TRIZ appeared in 1956, the first book – in 1961, the last version of inventive algorithm ARIZ prepared by G. S. Altshuller – in 1985. Since 1958 seminars on TRIZ have been conducted, at first by G. Altshuller and later by him and his team. In 1985 there were about 250 schools teaching TRIZ in the Soviet Union. After the collapse of Soviet Union several TRIZ experts travelled outside Russia and contributed to the education and application of this theory to various organizations, including many top companies, where innovations are needed. As an example Samsung has its own TRIZ department where TRIZ is taught and applied. There are associations that teach and promote the method including the International TRIZ Association [1], European TRIZ Association [2]. Many consulting and training companies teach and apply TRIZ (for example [3]). In 2015 there are 101 TRIZ masters certified by the International TRIZ association that know and apply TRIZ at a high level. G. S. Altshuller and his team wrote 15 TRIZ textbooks during 1961-1994. These books were written Russian, and some have been translated into English and other languages. To understand the essence of TRIZ, it is recommended to read the original books as they contain the ground for the theory and nuances that can be misinterpreted during translations. Therefore the knowledge of Russian is needed for the deep understanding of TRIZ. Articles by G. S. Altshuller can be found in official G. S. Altshuller Foundation (in Russian) [4]. The scientific community has an emerging interest in TRIZ as it helps to find new technical solutions. The Scopus database currently shows about 1300 articles when searched by keyword "TRIZ". The scientific community is showing increased interest in TRIZ insofar as innovation is becoming an obligation for majority of scientific work and is a significant element for the positive evaluation of project proposals.

In about 1989 [5] TRIZ contained a profound system of tools that helps to find technical solutions: 1) Algorithm of Inventive Problem solving – ARIZ; 2) Laws of technical system evolution; 3) Su-Field "language" to describe systems; 4) 76 standard solutions that uses Su-Field language; 5) database on physical, chemical, geometrical effects and their application in inventions; 6) guidelines for application of TRIZ for product evaluation and development (function – cost analyses – ФСА); 7) tools for the development of imagination; 8) guidelines for the development of creative personality. New developments include suggestion in which order to use these tools [6].

Current poster includes all main tools of TRIZ (some tools are briefly mentioned) and therefore it is useful for educational and application purposes. Future developments will be application of these tools in specific systems to find new solutions.

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Report on the Conference "The Next giant leap: Leveraging lunar assets for sustainable pathways to space", Hawaii Island, USA, November 9-13, 2014

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The Conference co-sponsored by FOTONIKA-LV was held in Hawaii November 9-13, 2014 [1]. The aim of the conference was to discuss ways to leverage assets of the Moon including its natural resources as well as its proximity to the Earth as well as infrastructure in cislunar space to develop sustainable pathways for permanent operations in space (research and commercial) beyond Earth orbit. About 50 participants including Buzz Aldrin the second man on the Moon, were present with affiliations from governmental structures (NASA, ESA, and other), research institutes (FOTONIKA-LV and other) and private companies (Boeing and other). The conference revealed that a theme of lunar exploration is in the minds of many players, governments and commercial firms. Various technologies have already been developed or are under development (3D printer for lunar constructions, spacecraft, landers, rovers, space fuelling stations [2]). Plans for lunar exploration and lunar base construction have been announced by several space agencies both by national space programs [3,4], laws for Lunar Exploration [5,6]. Yet Lunar theme has not gained enough governmental support. The idea of an International Lunar Decade offers the potential to address technical and international political questions involved in lunar development.Hawaii was chosen for the conference as the volcanic surface of parts of Hawaii island are similar to the surface of the Moon and of parts of Mars and various space robotic tests are made there [7].

Fig.1. Participants of the conference

The Conference included the following plenary sessions:

- The Moon as a Catalyst for Sustainable Space Enterprise;
- Sustainable Pathways to Space: Challenges, Options and Opportunities;
- Space 2.0: A Multi-Participatory Approach;
- and other

A presentation on the International Lunar Decade and the Declaration for the Lunar Decade was given by V. Beldavs from Latvia via Skype with on site support from of A. Atvars who moderated the session.

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Cooperation in Space Technologies with Africa

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The FOTONIKA-LV research association of the University of Latvia in collaboration with the Space Technologies Cluster of Latvia and the firm Space Technology and Science Group, Oy based in Finland organized the conference International Conference on Collaboration in Space Technologies (ICCST) in Riga, Latvia June 5-6, 2014. The vision of the conference was that the Baltics, Central Europe together with the Nordic countries have developed a high level of space technology capabilities that can address critical needs in Africa. Conference participants included key people from the African Union Commission responsible for African Union space policy including Dr. Abdul Hakim Elwaer, Director Human Resources, Science and Technology Department as well as Dr. Mahamma Quedraogo, Head of Division, Human Resources, Science and Technology Department. Ethiopia, Nigeria, South Africa, and Zimbabwe also participated. Latvia, Czech Republic, and Finland participated as well as the European Commission and ESA. The Conference resulted in a Memorandum of Understanding signed between the African Union Commission and STSG. Several concrete projects have resulted from ICCST including projects to launch satellites as well as the development of a master's level program in space science. An additional project is to provide assistance to the African Union Commission to develop a space policy for the African Union. ICCST was opened by former President of Latvia Dr. Vaira Vīķe Freiberga as well as with introductory remarks by Dr. Ina Druviete, Minister of Education and Science. The Program [1].

References

[1] ICCST Conference Program – *http://www.iccst.eu/index.php/schedule*

FOTONIKA-LV and the International Year of Light

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The FOTONIKA-LV research association of the University of Latvia serves as a national contact point for the UNESCO 2015 International Year of Light initiative[1] (IYL2015). The global mission of IYL2015 is similar to the national mission of FOTONIKA-LV:

> *In proclaiming an International Year focusing on the topic of light science and its applications, the United Nations has recognized the importance of raising global awareness about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health. Light plays a vital role in our daily lives and is an imperative cross-cutting discipline of science in the 21^{st} century. It has revolutionized medicine, opened up international communication via the Internet, and continues to be central to linking cultural, economic and political aspects of the global society.*

FOTONIKA-LV began its IYL2015 activities with the Day of Photonics seminar at the Riga Photonics Center on 21 October 2014[2] to which were invited representatives from research, industry and public policy regarding photonics from Estonia, Latvia and Lithuania. Several initiatives are planned in 2015 including a joint initiative with the Riga City Council for the White Night event that will feature a photonics installation at the Riga Photonics Center on 6-7 September 2015. The overall plan of FOTONIKA-LV for IYL2015 will be presented.

Fig.1. Logo of the International Year of Light 2015

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A Simple Cost-effective Digital System for Tuning and Long-term Frequency Stabilisation of a CW Ti:Sapphire Laser

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We have implemented a simple and cost-effective digital system for long-term frequency stabilisation and locking to an arbitrary wavelength of the single-frequency ring CW Ti:Sapphire laser. This system is built using two confocal Fabry-Perot cavities, one of which is used to narrow short-term line width of the laser and the other to improve long-term stability of the laser frequency. The length of the second cavity is stabilised using the radiation from an external-cavity diode laser locked to an atomic transition. Our system is an improvement of a commercial Tekhnoscan laser lock.

Scheme of the experimental setup is shown in Fig.1.(a). The Ti:Sapphire laser is locked to cavity 2 using side-fringe locking technique. Cavity 1 is scanned at 200 Hz by an amplified function generator. We use the ramp voltage from the function generator for synchronization as shown in Fig.1.(b). The transmission peaks from two lasers are detected on the photodiode PD1, as shown in Fig.1(c), and recorded using ADC, and analysed on a computer. The feedback signal is calculated from the ratio of the time delays between the transmission peaks and is sent to the PZT of cavity 2. We have used this system to lock the Ti:Sapphire laser at 743 nm for three-step laser excitation of cold rubidium atoms into the Rydberg states.

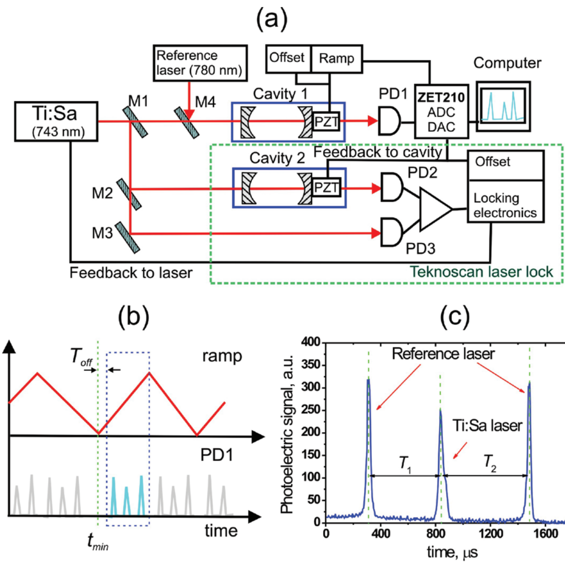

Fig.1. Scheme of the experiment

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Nonlinear Optical Pumping of a Slow and Cold Cs Beam

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A cesium beam is produced out of a modified pyramidal Magneto-Optical Trap used as an atomic funnel [1]. Briefly, the trapping and repumping radiations are sent into an arrangement of prisms and mirrors shaped in the form of a hollow pyramid, realizing the beam configuration of a standard MOT. A hole (area ≈2mm^2) is drilled at the pyramid apex, hence no laser radiation is retroreflected along the pyramid axis. A continuous beam of atoms is then leaving the hole with longitudinal velocity around 12 m/s. Right after the hole, the beam is collimated by 2-D transverse optical molasses.

We investigated the dynamical aspects of the excitation process in the atoms belonging to the beam, slowly moving through a weak resonant excitation radiation with a Gaussian profile. The populations of the $6^2P_{3/2}$ HF sublevels F_e=3,4,5 have been probed in a two-photon photoionization scheme with a low ionization rate, leading to negligible perturbation. The comparison of the experimental data [2] with results of accurate numerical simulations highlights the effects of optical pumping phenomena under a weak excitation limit, involving both hyperfine and Zeeman structure of the energy levels. Thanks to the long transit time (≈100m*s*) enabled by the sub-thermal velocity of the beam, even a tiny mixture within the HF sublevels, due to the excitation laser coupling, results in essential modifications of the optical pumping effects. In particular, the circular transition $6^2S_{1/2}$, F_g=4 → $6^2P_{3/2}$, F_e=5 becomes semi-open due to the laser stimulated mixing between sublevels F_e=5 and F_e=4.

This work was supported by the EU FP7 Programme through the MC-IAPP Project "Coldbeams" and EU FP7 Centre of Excellence FOTONIKA-LV.

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Concept Project of Microwave Plasma Torch Based 3-D Printer for Hard Melting Materials

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Some years ago thanks to K.Gross grew an idea and the project afterwards /1/ that there is benefit to make an experimental 3-D CNC printing device for hard-melting materials like apatites, opening the potential to grow human-bone compatible medical implants. However all our trials to heat plasma enough to let calcium nanoparticles to reach ~2000 C temperature were "too cold". Knowing the Belorussian ITMO institute has world class excellence about the plasma torches, we made a visit and concluded a scientific collaboration plan; they explained, as higher frequency, as more balanced plasma behave, therefore we should use a microwave (MW) torch. Thus we were allowed to make to some extent a copy their system and the rest we adapted to our needs. We modified the electronics to eliminate components from Russia.

Thus, the system of high-melt MW torch consists of number of modules:

First is Ca 2 kW AC-DC CC/CV stabilized SMPS fed by PFC, exit voltage about 3kV and 0,8A. In circuitry we have proven two versions, simple without PFC and more complex according EU Directive about obligatory use of PFC. All the details fit into a one liter volume, thus the unit is nicely miniature yet powerful, made on the IGBT and non-expensive chipset.

Next is MW cooker magnetron fed by this SMPS, radiating into Launcher WR340, that is connected to Circulator. Circulator is loaded by Water Load paralleled by MW diode R451570, that enables system tuning. Circulator exit is connected to a 3-knob Tuner WR340, that is loaded just by λ/2 straight section, ended by hard cover mirroring energy backward. Holes are made in the point of λ/4 where a double wall coaxial quartz tube is inserted in the inner organize Argon flow. Electronic Fluid flows in the walls (which has extremely low epsilon), for cooling needs. Finally an igniter is needed that gives short pulses of cold high-voltage plasma. It may be substituted with manipulations of the system vacuum, if permitted. For the igniter we used the ITMO patented idea that 1 MHz oscillator pulls MOSFET half-bridge, that feeds the ferrite core voltage transformer tuned into resonance, therefore having Q-fold voltage rise-up factor. As soon the MW plasma had ignited, plasma shortens the transformer`s uniform capacitance and winding becomes de-tuned, thus giving Q times less voltage. At last, the commercial Hall effect sensor was used to switch off the 1 MHz generator completely, as soon as the large MW current reaches stability. Today this system is under design and soon we hope to see first results. If it will be positive, then it will become possible to produce synthetic human bone elements from CAD drawings or 3-D scans. The process also looks promising to develop equipment for 3D printing of many other hard-melting materials.

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GNSS More Than A Tool For Navigation

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GNSS (*Global Navigation Satellite System*) is freely accessible to anyone with a GNSS receiver for location, velocity and time anywhere and in any weather when signal from 4 or more satellites is available. Most modern GNSS receivers rely not only on the more known GPS but also on the more recent set of satellites of GLONASS for a more accurate location due to more satellites being visible.

Each satellite caries several Rb atomic standards on board to transmit the time and the location of the satellite. This information can be used for more than just calculating the location of the receiver but also as a source of accurate time. It can be used as a reference clock to discipline a Rb clock on Earth. These Rb clocks are the frequency standards but they might drift by approximately 10^{-11} per month. Satellites can be used for long term stabilization of the oscillator in the Rb standard. This takes approximately 10,000-100,000 s to reach the best stability. Why would one need a more accurate Rb clock? The Rb frequency standard is a likely weak point for creating optical frequency standard using femtosecond frequency comb to create an even better and accurate frequency standard and clock.

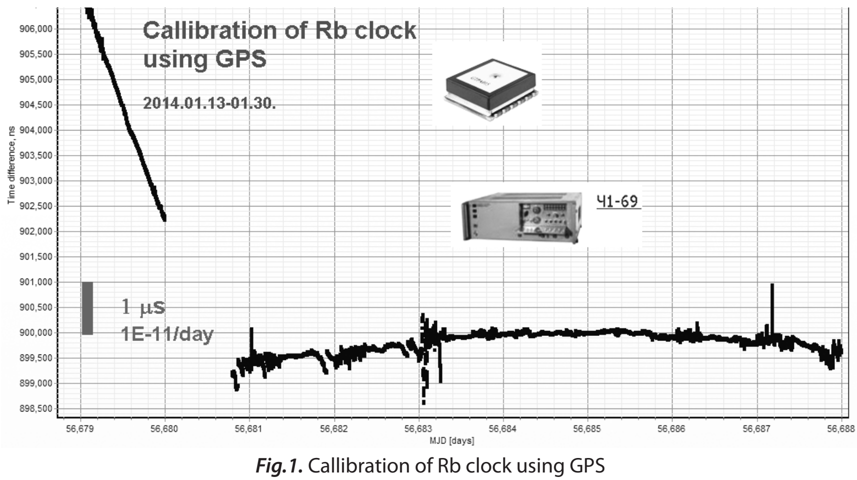

Fig.1. Callibration of Rb clock using GPS

In Fig.1. – One week of measurement of rubidium microwave clock 1 pulse per second output against GPS time allowing to extract the actual frequency of the Rb clock. Rb clock drift was large during the first day of measurement and was corrected by adjusting the internal compensation magnetic field of the Rb standard. GPS signal can get spiky on some days with large solar activity. So each clkock is good for different time intervals. Rb clock is better than GPS for several hours time but GPS allows to maintain stability over days and years.

The FOTONIKA-LV Project "An International Network on New Strategies for Processing of 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 7 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;
- Department of Pathology , University of Adelaide, Australia.

Initially planned cooperation with the Department of Chemical Engineering and Biotechnology, National Taipei University of Technology, Taiwan now will be based on other joint projects but still will bring assets to the project results.

The project past the first year milestone and all partners are activated in secondment exchanges. Remarkable success is intensive collaboration via both-way secondment visits exchange between Tomsk Polytechnic University and both universities in Latvia. There is mutual interest, colleagues from Russia can contribute with more human capacity, but Latvia side has better research infrastructure. These activities are going to benefit from contribution of colleagues from the Institute of Heat and Mass transfer, National Academy of Science of Belarus. The progress is made in advancing the high temperature 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 in two ways:

- with radiofrequency (RF) inductively coupled plasma as a new processing tool in clean high temperature processing environment;
- with microwave produced plasma.

The first secondment visits from Canada to Riga and secondment visits from Latvia to Australia are also performed. Joint research efforts already resulted in scientific paper ready to be published and in 2 reports in International conferences.

The main problem is complex logics of secondment visits among partners which should carefully adjusted to ensure knowledge transfer, collecting of critical mass of human capacity and training of young researchers.

Earth Tide Observations and Analysis Methods

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Because the Earth tides are so small in comparison with ocean tides, building instruments to detect them has long been a challenge, though an easier one over time, as sensitive transducers and digital recording have become more readily available [1]. The earliest measurements were of tidal tilts, and over the years a wide variety of tiltmeters has been designed and is used. Different types of strainmeters sensitive to tidal deformations are also widely used.

The second type of Earth tide detection was to measure changes in gravity, and many such measurements have been made with a variety of types of gravimeters [2]. The newest procedures for measuring Earth tides are the techniques of space geodesy: Very Long Baseline Interferometry (VLBI), Global Navigation Satellite Systems (GNSS), as well as Satellite Laser Ranging (SLR).

The goal of the tidal analysis is mainly to determine the amplitude ratio between the observed tidal amplitude and the modeled one (body tides) as well as the phase difference between the observed tidal vector and the theoretical one. Moreover, the tidal loading due to the corresponding oceanic tidal waves cannot be separated from the body tides as they have practically the same spectrum, as the result the superposition of both effects is observed. The only way to determine the true body tides is to compute the tidal loading vector by integrating the oceanic tidal vector over the whole ocean [3].

The tidal analysis demand careful data recording and precise calibration of the instruments, as well as to the detection of the anomalous parts of the records.

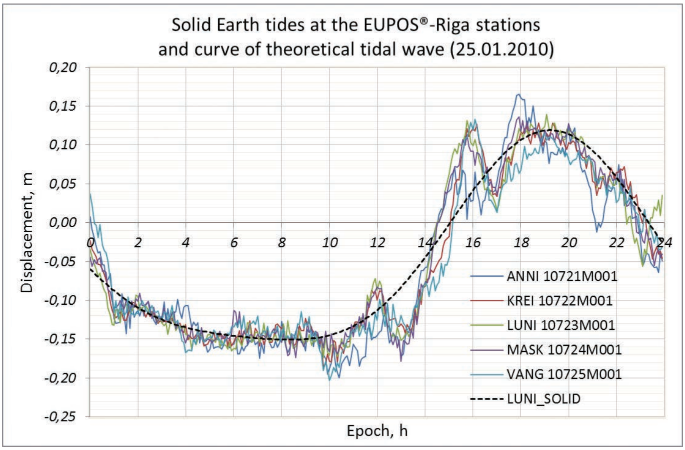

Fig.1. Tidal displacements at GNSS stations of the EUPOS®-Riga network and the theoretical curve of body tides.

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Penning Ionization of a Non-symmetrical Atomic Pair in a Rydberg Gas

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A study of Penning ionization (PI) in collisions of two cold Rydberg atoms is presented. We have determined the dependence of the auto-ionizing width on the parameters of Rydberg states of the atomic pair involved into the dipole-dipole interaction. It is revealed a novel counterintuitive phenomenon of a pure quantum-mechanical nature. The auto-ionization width appears to sharply increase (in two orders of magnitude) when the principal quantum number of the de-exciting atom decreases. We have provided a theoretical treaty of the discussed problems and found an optimal configuration with the maximum PI rate for a hydrogen two atom system. Due to specific features inherent to the evolution of a cold Rydberg gas resulting in production of quite non-symmetrical states the Penning process may acquire a noticeable role in the formation of cold plasma.

Dust Particle Counting in Ambient Laboratory Air

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Dust particles in the air are one of major obstacles in high power laser spectroscopy involving optical resonators. Usually in laser laboratory air conditioning using filtration is necessary. This is especially important if the laboratory is situated in urban environments where besides dust carbon soot nanoparticles are present from car exhaust and furnaces.

Air cleanness is also important in medical aspect – pollen from grass, flowers and trees in nature is causing asthma and allergies for some people [1].

We examined the air quality using a commercial dust sensor (Sharp GP2Y10) using an Arduino board for data recording and analysis. A fan was used to accelerate the air flow through the sensor. The data was displayed using an LCD monitor. We found the precision was not sufficient for our application, so we constructed a custom sensor.

In our custom-built sensor a 1W laser diode light was directed at the particles and Mie scattering was observed and recorded by a digital camera. The camera's data was processed using LabVIEW image processing tools. This allowed us to achieve a high precision in detecting both the size and number of the dust particles.

Using this sensor we were able to evaluate the cleanliness of the air as well as the efficiency of several air filtering methods.

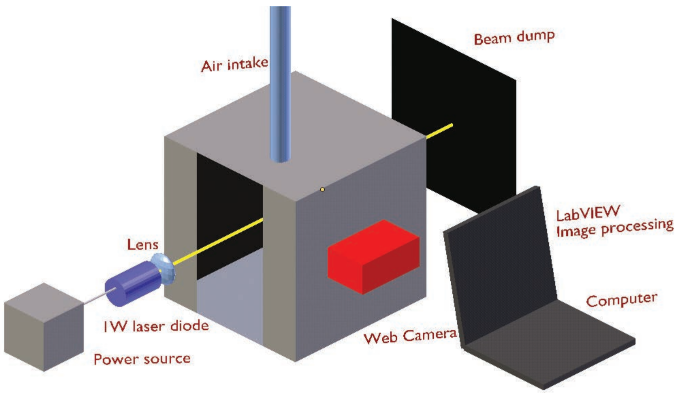

Fig.1. Custom built particle sensor.

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Development of Laser Beams Coaxial Direction Active Stabilization on Interoperable Remote Platforms

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There are needs for coaxial active stabilization of laser beams spatial axes between linked platforms at medium (some km) and large distances in atmosphere in different applications for example in atmosphere research and monitoring applications, free space optical links, femtosecond frequency combs applications etc. To realize field experiment of laser beams coaxial direction active stabilization between interoperable remote platforms the new laser beam spatial axis coaxial stabilization system meets the following challenges discussed in this work:

- Ensure the laser beams spatial axes coaxial active stabilization between linked permanently positioned platforms placed on unstable constructions, within few arc seconds
- Used lasers spectral range: from Visual till IR (1,600 nm)
- The platforms are designed for work in the field in harsh climatic conditions
- The platforms are designed for a variety of optical hardware payload.

The block diagram and description of field experiment of laser beams coaxial direction active stabilization between interoperable remote platforms are given.

This report results of a study which was carried out on a contractual basis between Latvian electrical and optical (LEO) equipment industry center of expertise (LEO RESEARCH CENTRE Ltd) and HEE Photonic Labs Ltd, Project No. KC /2.1.2.1.1./10/01/005, No. contract L-KC-11-0006, Research No.1.15.

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 coordinator of the project **"Nocturnal Atmosphere", FP7-PEOPLE-2011-IRSES.** There are 4 more partners in the project consortium:

- 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 and the Institute of Fundamental Problems for High Technology (IFPHT), National Academy of Sciences of Ukraine;
- Central Institute of Aviation Motors Scientific Research Center "Raduga" .

The project has four Work Packages and substantial progress was made for the first and the third one:

- 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.

Despite the politically stressed political situation sometimes putting the project in "force majeur" conditions the intensity of secondment exchange has been increased especially for collaboration between colleagues in Ukraine and Latvia. Besides several visits from Latvia to the Central Institute of Aviation Motors Scientific Research Center "Raduga" were conducted and a technician from Riga received a significant opportunity for training at the Advanced Laboratory of Plasma Spectroscopy. Experienced researcher in theoretical physics spent several months working together with colleagues on theoretical aspect of nocturnal atmosphere photochemistry and now are evaluating opportunities for a HORIZON 2020 MSCA fellowship project. The results of the project were reported in two conferences:

- 1st International Conference, Nocturnal Atmosphere and Laser Ranging: NOCTURNAL – Riga 2014;
- "6th International Symposium on Non-equilibrium Processes, Plasma, Combustion and Atmospheric Phenomena" in Sochi, Russia on October 6-10, 2014.

The Main Deliverables of BIOSENSORS-AGRICULT Project, FP7-PEOPLE-2012-IRSES, Contract No. 318520, (2012-2016)

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BIOSENSORS-AGRICULT project is targeted to staff exchanges between EU and non-EU countries in the fields of nano-, bio- and biosensor technology.

The project partners represent high ranked EU universities (University of Latvia, Riga, Latvia; University of Linkoping, Linkoping, Sweden; European Institutes of Membranes Montpellier, France) and leading Eastern European institutions (National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine; Institute of Biophysics and Cell Engineering, Minsk, Belarus; Odessa National I.I. Mechnikov University, Odessa, Ukraine). The project called on the scientific excellence of participating early stage and experienced researchers.

The transfer of knowledge and formation of an intellectual "critical mass" occured through theoretical exercises and laboratory research in the important and growing field of optical fibre biosensors, aiming towards applications in agriculture and taking opportunities offered by the latest achievements in nanotechnology and biotechnology. The challenge is to create unique devices for detecting animal diseases, viruses and toxins using fundamental phenomena such as light absorbance, reflectance, transmittance, fluorescence and photoluminescence.

The consortium provides its theoretical and experimental experience and specific skills for making advances in research on biosensors for agriculture applications. The project objectives are achieved via joint research on specific tasks in work packages.

The transfer of knowledge has been organized via seminars, workshops, conferences, summer schools and training courses. Through these, the results have been disseminated effectively and effective interactions have been stimulated between experienced researchers and a team of young researchers, PhD and MSc students.

The main achievements for 2013-2014 years were following:

- 6 scientific seminars;
- 13 publications in peer reviewed journals;
- 12 conference theses and 10 invited talks;
- co-organization of 2 workshops and 2 conferences;

Training of early stage researchers has been performed and 3 new publications have been accepted in 2015 with additional ones expected.

Project of Multipurpose Optical Tracking Device – Progress Report

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Since January, 2014 the Institute of Geodesy and Geoinformatics and Institute of Physics of the University of Latvia are engaged in a joint ESF-funded project whose planned outcome is a functional prototype of new multi-purpose optical tracking system for both positional and laser ranging observations of near-Earth objects (NEO). The system is being designed using many off-the-shelf components, and should be considerably cheaper than most analogues.

The principal technical features will be:

- twin 40 cm Meade catadioptric main optical systems,
- Independent collimator for transmitted laser beam,
- Positioning system supports tracking of any orbital object,
- positioning accuracy within a few arcseconds,
- possibility of simultaneous positional and SLR observations,
- astrometric position accuracy within a fraction of arcsecond for objects with optical magnitude up to 15^m,
- SLR capability (depending on laser transmitter) up to geostationary orbit,
- Possibility to combine usage of both optical systems in various ways.

Presently the CAD design stage is done, the main mechanical components have been manufactured, and all principal off-the-shelf components have been purchased. Components are now being prepared for assembling. Most software modules are ready for functional tests. According to plans, operational tests of device are expected to start in the second half of 2015.

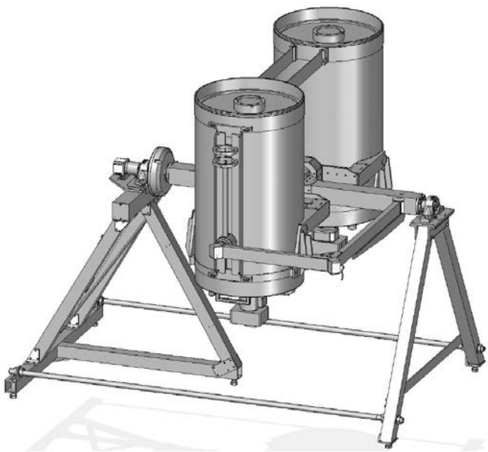

Fig.1. Design of device

Study on Collisions of Atomic Clusters with Charged Particles

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The research on atomic and molecular clusters is an active field and plays an important role in many branches of science [1]. Neutral and ionic clusters present in the atmosphere have a vital role for gas phase chemical reactions. Such reactions affect our climate and their investigation is crucial to understand the atmospheric processes in molecular level [2]. From small to large clusters, *(such as C60)*, carbon clusters provide fascinating examples of molecular structure and bonding [3]. Small carbon clusters play an important role in astrophysics, combustion [4] and in the formation of cosmic dust [2]. The investigation of the environmental clusters covers a broad spectrum of research areas. Clusters play a key role for the complex chemistry occurring in the upper atmosphere. Clusters have increasing applications in technology, such as, in controlling of surface properties, fabrication of micro structures on solid surfaces, miniaturizing components for modern present day electronic industry [2]. Clusters are popularly used for preparing new classes of materials with enhanced optical, magnetic, chemical and photo-catalytic properties, and clusters are used as an ideal catalyst in chemical industry [2]. Thus information obtained from cluster properties and behavior benefits wide community of basic science and material research.

With the aim of studying the collisions of atomic and molecular clusters with charged particles, we are developing a complete experimental setup. The experimental setup will consist of a cluster source, an ion source and a detection system. The cluster source is based on a supersonic jet expansion. In this source, a high pressure gas is expanded from a high pressure region *(few atmosphere*) to low pressure region. The core of the beam is extracted by a conical skimmer. The cluster beam is then subject to collide with an ion beam generated by an ion source known as Gothenburg-Riga Ion Beam Apparatus (GRIBA). GRIBA has a filament source to generate a positive ion beam of micro-ampere scale current of the substance evaporated under 2000 C. Ions are extracted from the plasma followed by focusing, acceleration and then filtering by a Wien filter. The product species generated through the cluster-ion collisions will be detected by a detection system, Time of Flight (TOF) mass spectrometer in our case. The TOF is acquainted with Micro Channel Plate (MCP) detector. The development of the complete setup is in process.

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Mitochondrial Bio-Sensing with Biomolecular Markers: Optical Microscopy and Flow Cytometry vs. Bioelectronics Approach

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Being the subject of cellular biology of animals and plants, mitochondria now become a target for mitochondrial biomedicine and biotechnology. Therefore it is vitally important to measure mitochondria function and dysfunction in living cells as well as it is necessary to know how to target mitochondria with biomolecules and drugs in order to treat and prevent the pathologies and control the stress response.

Using potential- and Ca^{2+}-sensitive fluorescent probes and methods of confocal microscopy and flow cytometry, we studied the stress-induced changes of mitochondrial membrane (MM) potential and transmembrane Ca^{2+} transport. In a series of tests, we evaluate the mitochondrial Ca^{2+} uptake driven by the MM potential, the effect of calmodulin and its antagonists on the MM polarization and Ca^{2+} content, as well as Ca^{2+} accumulation in depolarized mitochondria under the action of modulators of Ca^{2+} exchange [1].

As is known, in cell mitochondria are interconnected metabolically with peroxisomes. Despite being distinct structures, both organelles cooperate in regulation of ROS content. Stress-induced malfunction of mitochondria leads to accumulation of ROS that triggers proliferation of peroxisomes [2]. Our future projects will focus on studying cellular and molecular mechanisms and determination of signaling events, underlying mitochondria dysfunction and proliferation of peroxisomes during the stress response.

Among possible bio-sensing concepts, which can be used in the future, two specific approaches are of our special interest. One is based on electronic field-effect transistors (FET) with nanowires, another is microwave whispering-gallery-mode (WGM) resonators with microfluidic channels. Both approaches provide a lot of advantages such as fast response, high specificity and sensitivity, compatibility with optoelectronics, possibility of integration of biosensor arrays into the portable lab-on-chip analytical instrument and optimization to study complex biological objects at nanoscale [3].

New bio-sensing technology proposed is based on the idea to apply both nanowire FET electronics and microfluidic WGM resonators for characterization of mitochondrial bio-markers as biosensors. It is expected that such approach will provide high sensitivity and selectivity of mitochondrial bio-sensing and diagnosis because both techniques have above-mentioned specific advantages. Research is in progress.

We acknowledge the support of EU FP7 REGPOT-CT-2011-285912 FOTONIKA-LV, FP7-PEOPLE-IRSES-2011-204949 NOCTURNAL ATMOSPHERE, and FP7-PEOPLE-IRSES-2012-318820 BIOSENSORS-AGRICULT.

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Horizon 2020 SME Instrument for SMEs in Latvia

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Horizon 2020 provides a new attractive project option not found in earlier structure fund programs called the SME Instrument [1]. It supports individual SMEs in developing a new product for market readiness. The SME instrument consists of three separate phases – Phase 1 for feasibility study *(50,000 EUR, 6 months, 70% EU co-financing)*, Phase 2 for product prototyping and introducing to market *(0.5-2.5 MEUR, 1-2 years, 70% EU co-financing*), and Phase 3, mentoring for SMEs that have received financing in Phase 2. Calls are opened about every three months – for Phase 1 in 2014 cut-off dates were 18/06/2014, 24/09/2014, 17/12/2014, in 2015 cut-off dates will be 18/03/2015, 17/06/2015, 17/09/2015, 16/12/2015.

In 2014 Association FOTONIKA-LV took active steps in promoting the SME instrument call for SMEs in Latvia as a service to firms that are involved in the photonics, quantum sciences, space sciences and related technologies cluster. A separate section in a WEB page of FOTONIKA-LV was made to describe this call [2]. Phase 1 of the SME instrument generated the most interest. The first success for Latvia with the SME Instrument was the winning of a Phase 1 project "*Hybrid cooling system for semiconductor detectors of X- and Gamma- Rays",* Project acronym "SEMICOOL-H", of Baltic Scientific Instruments (BSI), Ltd. [3]. This proposal was written by the active involvement of director of BSI – Vladimir Gostilo – and a group from FOTONIKA-LV. The project was submitted for the 24/09/2014 deadline.

For SME Phase 1 the following data reveal activity of SMEs:

- For 18/06/2014 call – 162 projects financed [4];
- For 24/09/2014 call – 1944 projects submitted [5] and 199 financed [4];
- For 16/12/2015 call – 2363 projects submitted [5];
- For first two calls of SME instrument Phase 1 *(deadlines 18/06/2014 and 24/09/2015*) the following number of beneficiaries was financed from Baltic States [4]: Latvia – 1, Lithuania – 2, Estonia – 7. On 26.01.2015. for Phase 2 [6] there were 4 beneficiaries from Estonia, and none from Latvia and Lithuania. From Latvian Nation Contact Point we can obtain data of submitted documents from Latvia: in 18/06/2014 Phase 1 – 15 projects were submitted and none financed, in 24/09/2014 – 12 projects were submitted and one financed.

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Scientific Collaboration with Ukrainian SLR network

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The scientific collaboration between Latvian research institutions with Ukrainian SLR network has a decades long history. Another important aspect is that the SLR station Riga and Ukrainian SLR systems are using the same satellite laser ranging telescope – LS-105. This poster will discusses current status of this collaboration including scientist exchange programs and currently ongoing activities to improve LS-105 performance and knowledge transfer in the field of SLR.

Differential Approach and Radiation Amplification Factor

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Differential approach to processing of experimental data is based on dimensionless sensitivity [1]. Mathematically it is described by equation: $\alpha(x) = \frac{d(\lg y)}{d(\lg x)} = \left(\frac{x}{y}\right) \times \left(\frac{dy}{dx}\right)$, where x is argument and y is function. In such case the approximation of function could be presented in the form $y=Ax^{\alpha}$. One important factor for the estimation of climate change is the radiation amplification factor (RAF) defined as the percentage increase in the biologically active UV irradiance, or exposure (UV_{bio}) that would result from 1 % decrease in the column amount of atmospheric ozone [2]. Its approximation could be described as $UV_{bio} \sim (Ozone)^{[-RAF]}$. Actually radiation amplification factor and dimensionless sensitivity have general mathematical base [3]. Processing of investigated theoretical or experimental characteristics by such an approach permits us to determine the peculiarity of their behaviour and compare values with different physical or other characteristics. Use of a comprehensive mathematical tool gives new possibilities for investigation of UV effect mechanisms. The range of α =const will characterize definite mechanisms of UV effect. From the other hand, such analysis can recognise these mechanisms. As the example [2] we represent the data for UV effect on human skin at 30°N:

Effect	RAF		Reference
	January 290DU	July 305DU	
Skin			
Erythema Reference	1.1	1.2	A. F. McKinlay and B. L. Diffey, 1987
Skin cancer in SKH-1 hairless mice (Utrecht)	1.5	1.4	F. R. deGruijl et al., 1993
SKH-1 corrected for human skin transmission	1.2	1.1	F. R. deGruijl and van der Leun, 1994
Elastosis	1.1	1.2	L. H. Kligman, R. M. Sayre, 1991
Photocarcinogenesis, skin edema	1.6	1.5	C. A.Cole et al., 1986
Photocarcinogenesis (based on STSL)	1.5	1.4	G. Kelfkens et al., 1990
Photocarcinogenesis (based on PTR)	1.6	1.5	G. Kelfkens et al., 1990
Melanogenesis	1.7	1.6	J. A. Parrish et al., 1982
Erythema	1.7	1.7	J. A. Parrish et al., 1982

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