Laserlab Europe User Meeting

27-29 August 2017

Vilnius, Lithuania

Book of Abstracts

Contact:
www.laserlab-europe.eu

27 August 2017	
16:00	Excursion to Laser Research Center (I), Meeting Place: Universiteto st. 3
18:00	Excursion to the old city of Vilnius and old building of Vilnius University (I)
20:00-22:00	Welcome party, Universiteto st. 3
28 August 2017 – Aula Parva – the Small hall of Vilnius University, Universiteto st. 3, Vilnius	
09:30-09:40	Welcome addresses — Rector Arturas Zukauskas, Vilnius University Valdas Sirutkaitis, VULRC, Vilnius University Algis Petras Piskarskas, Lithuanian Laser Association
09:40-10:10	Transnational Access to Laserlab-Europe Didier Normand, Chair, Laserlab-Europe Access Board
	Session Ia: *High intensity interactions and plasma physics* Chair: Istvan Földes, Wigner Research Centre for Physics, Hungary
10:10-10:30	Ross Gray, University of Strathclyde, UK *"Influence of focal spot geometry on energy absorption in intense laser-solid interactions"* (project performed at GSI)
10:30-10:50	Katerina Falk, ELI Beamlines, Institute of Physics, ASCR, Czech Republic *"Highly efficient angularly resolving x-ray spectrometer optimized for absorption measurements with collimated sources"* (project performed at LLC)
10:50-11:20	*Coffee Break*
11:20-11:40	Stephan Kraft, Helmoltz-Zentrum Dresden-Rossendorf (HZDR), Germany *"Laser-driven proton acceleration from a solid hydrogen ribbon"* (project performed at LULI)
11:40-12:00	Jayanath Koliyadu, IPFN, Instituto Superior Tecnico, Portugal *"Calibration of XUV Optics and high NA Hartmann wave front sensor"* (project performed at LOA)
12:00-13:00	*Round table*
13:00-13:05	*Picture of participants at the entrance to Vilnius University*
13:05-14:20	*Lunch*
	Session Ib: *High intensity interactions and plasma physics* Chair: Arunas Varanavicius, VULRC
14:20-14:40	Alan Miscampbell, University of Oxford, UK *"Relativistic Laser-Plasma & Atomic Physics Studies Using Nanowire Targets"* (project performed at LULI)
14:40-15:00	Enda McGlynn, Dublin City University, Ireland *"Field Enhancement of Multiphoton Induced Luminescence Processes in ZnO Nanorods"* (project performed at MBI)
15:00-15:20	Zofia Kalinowska, Institute of Plasma Physics and Laser Microfusion, Poland *"Application of the femtosecond multi-frame interferometry in research on PALS facility, related to shock ignition concept of inertial fusion"* (project performed at PALS)
15:20-15:40	Tomasz Chodukowski, Institute of Plasma Physics and Laser Microfusion, Poland *"Comprehensive investigation of ablative plasma with using femtosecond polaro-interferometry for applications in inertial confinement fusion and astrophysics"* (project performed at PALS)
15:40-16:20	*Coffee Break*
14:20-16:20	Laserlab Access Board Meeting (in parallel, Room 238)
16:30	*Departure to Trakai (http://www.trakai-visit.lt/)*
19:00	*Meeting Dinner*
23:00	*Return to Vilnius*

29 August 2017 – Aula Parva – the Small hall of Vilnius University	
	Session IIa: *Life sciences & biotechnology and molecular and cellular biology* Chair: Jouko Korppi-Tommola, University Jyväskylä, Finland
9:30-09:50	Mary Pryce, Dublin City University *"Novel Therapeutic Agents: Metal Carbonyl Complexes"* (project conducted at CLF)
09:50-10:10	Craig Lincoln, TU Vienna, Austria *"The role of molecular vibrations in photosynthetic light harvesting"* (project performed at CUSBO)
10:10-10:30	Sebastjen Schoenaers, University of Antwerp, Belgium *"Single Plane Illumination Microscopy to study calcium oscillations in growing Arabidopsis root hairs"* (project performed at CUSBO)
10:30-10:50	Vitali Zhaunerchyk, Department of Physics, University of Gothenburg, Sweden *"Infrared Action Spectroscopy of Low-Temperature Nonaromatic Peptides in Gas Phase"* (project performed at FELIX)
10:50-11:20	*Coffee Break*
	Session IIb: *Life sciences & biotechnology and molecular and cellular biology* Chair: Ingo Fischer, University Wuerzburg, Germany
11:20-11:40	Domenico Doria, Queen's University Belfast, UK *"Proton irradiation of human cell lines at ultrahigh dose rates"* (project performed at LULI)
11:40-12:00	Jana Janocková, Biomedical Research Centre, University Hospital Hradec Kralove, Czech Republic *"Potential inhibition effect of $A\beta_{1-42}$ self-aggregation kinetics"* (project performed at CLL)
12:00-12:20	Eugen Koch, Institute of Microtechnology, Germany *"Femtosecond laser micromachining of a cell cultivation membrane in photosensitive glass"* (project performed at VULRC)
	Session III: *Cultural heritage investigations with lasers* Chair: Helder Crespo, University of Porto, Portugal
12:20-12:40	Haida Liang, Nottingham Trent University, UK *"Optical coherence tomography and non-linear microscopy for paintings - a study of the complementary capabilities and laser degradation effects"* (project performed at IESL-FORTH)
12:40-13:00	Vadim Parfenov, St. Petersburg State Electrotechnical University, Russia *"The spectroscopic analysis of pigments of wall paintings from archeological findings on territory of Russia and former Soviet Union"* (project performed at LENS)
13:00-14:00	*Lunch*
	Session Ic: *High intensity interactions and plasma physics* Chair: Valdas Sirutkaitis, VULRC
14:00-14:20	Piotr Raczka, Institute of Plasma Physics and Laser Microfusion, Poland *"Strong electromagnetic pulses generated in high-intensity fs laser interaction with thin foil targets"* (project performed at CELIA)
14:20-14:40	Hamed Merdji, CEA Saclay *"Amplification of solid laser harmonics in resonant nanostructures"* (project performed at ICFO)
14:40-14:50	Closing remarks
15:00-17:00	Excursion to Laser Research Center (II)
17:00-19:00	Excursion to the old city of Vilnius and old building of Vilnius University (II)

Influence of focal spot geometry on energy absorption in intense laser-solid interactions

R.J. Gray[1], R.Wilson[2], S.D.R Williamson[1], M. King[1], R.J. Dance[1], C. Armstrong[1,2], C.Brabetz[3], F. Wagner[3], B. Zielbauer[3], V. Bagnoud[3], D. Neely[1,2], and P. McKenna[1]

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The absorption of laser energy into dense plasma and the resulting production of hot electrons underpins a host of intense laser-driven radiation production mechanisms. Using a suite of novel diagnostics developed for the PHELIX laser (GSI), we measure the total reflected energy as a function of intensity and for the first time distinguish between the influence of laser energy and focal spot size on absorption. We demonstrate good agreement with previously published scaling of absorption with intensity by variation of laser pulse energy. However, we demonstrate a slower scaling of absorption with intensity when changing the focal spot size for constant laser pulse energy. For large focal spots we find an overall more favourable total absorption even for nonrelativistic laser intensities (< 10^{18} W/cm^2 for 1 µm wavelength) when compared with smaller focal spot geometries of equivalent intensity. The results of 2D particle-in-cell simulations, supported by an analytical model, indicate that the measured difference in scaling of absorption with focal spot size derives from changes to the induced curvature of the critical density surface and the refluxing electron population. We will present these new insights and discuss the implications for a broad range of topics in laser-plasma interactions, including for the generation of novel radiation sources and in the design of advanced fast-ignition fusion schemes.

Highly efficient angularly resolving x-ray spectrometer optimized for absorption measurements with collimated sources

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Highly collimated betatron radiation from a laser wakefield accelerator is a promising tool for spectroscopic measurements [1]. Therefore, there is a requirement to create spectrometers suited to the unique properties of such a source. We demonstrate a spectrometer which achieves an energy resolution of <5 eV at 9 keV ($E = \Delta E > 1800$) and is angularly resolving the x-ray emission allowing the reference and spectrum to be recorded at the same time. The single photon analysis is used to significantly reduce the background noise. Theoretical performance of various configurations of the spectrometer is calculated by a ray-tracing algorithm. The properties and performance of the spectrometer including the angular and spectral resolution are demonstrated experimentally on absorption above the K-edge of a Cu foil backlit by a laser-produced betatron radiation x-ray beam.

References:

[1] M. Šmíd *et al*., Rev. Sci. Instrum. **88**, 063102 (2017)

Laser-driven proton acceleration from a solid hydrogen ribbon

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In the last years, more and more high repetition rate ultrahigh power lasers are build. In order to use the novel capabilities in applications with laser accelerated ion beams, new target types have to be developed. These targets have to fulfil two conditions: they have to stand several hundreds or even thousands of shots and produce as less debris as possible in order to spare the expensive optics. Promising candidates are pure hydrogen targets.

Here we report on experiments with a solid hydrogen ribbon performed at the ELFIE facility in France and compare the results to shots on normal metal and plastic foils.

Calibration of XUV Optics and high NA Hartmann wave front sensor

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In the past decades, the soft x-ray source community has witnessed important milestones in the development of ultrashort coherent extreme ultraviolet (XUV) sources and ultrafast XUV imaging. So far, there have been several mechanisms to generate coherent XUV radiation from laser matter interaction. Good spatial beam quality of XUV sources is essential for applications like imaging, probing and hence the study of the wave front is required .

Due to the compact and easy to set up design, the Hartmann wavefront sensor (WFS) has been widely employed in many different XUV sources [1, 2, 3]. However, the existing XUV Hartmann WFS's prevents from characterizing XUV beams with larger divergence ($\sim 10's$ mrad) as encountered in solid high harmonics [4], EUV lithography and EUV microscopy due to the CCD chip size and Hartmann plate configuration. We report a new Hartmann WFS with high numerical aperture (NA ~ 0.1), which is competent for close-in detection of XUV sources ranging 4 nm to 44 nm. It consists of a holes-array plate placed at a distance of 50 mm from a large chip-size PI-MTE X-ray vacuum CCD (figure 1(a)). The WFS was calibrated with a high harmonic source ($\lambda \sim 32$ nm). Furthermore, we tested this novel sensor by characterizing the spatial quality of different XUV multilayer mirrors.

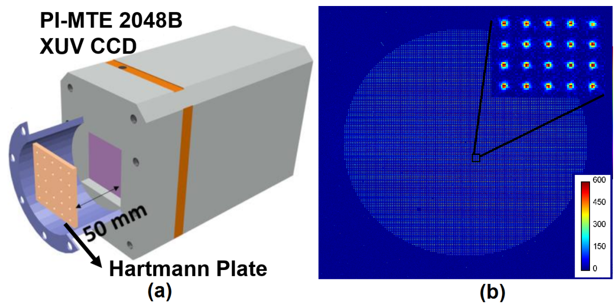

Figure 1: *(a) High NA Hartmann WFS, (b) A raw image from sensor calibration acquired in 30 minutes.*

References

[1] S. Le Pape et al, Physical Review Letters, **88**, 18 (2002)

[2] P. Mercére, et al., Optics Letters **28**, 1534-1536 (2003).

[3] L. Li et al., Optics Letters **38**, 4011-4014 (2013).

[4] B. Dromey et al., Nature Physics **5**, 146-152 (2009).

Relativistic Laser-Plasma & Atomic Physics Studies Using Nanowire Targets

Alan Miscampbell[1], *Oliver Humphries*[1], *Jeremy Li*[2], *Andrew Tan*[2], *Quincy Van den Berg*[1], *Frédéric Pérez*[3], *Sam Vinko*[1], *Robin Marjoribanks*[2]

One of the greatest challenges in experiments using high intensity lasers is absorption. A relativistic laser pulse, incident on a standard flat foil target, causes the target surface density to become sharply supercritical ($n > n_c$), reflecting much of the subsequent radiation. While some laser energy is still absorbed after the plasma forms, target heating relies on x-ray and electron transport within the material. The novel design of nanowires, first introduced for laser-plasma targets in 2000 [1], allows for up to 95% absorption on low energy (< 1 J) laser systems by manipulating the target surface, structured on a sub-wavelength scale (~ 70 nm), allowing ultra-intense light to propagate many microns through material with average e^- density $> n_c$. Some laser energy can then be deposited deep within the nanowire structure, allowing volumetric heating to very high energy densities ($\sim 100 n_c$ e^- density at keV temperatures) [2].

The primary purpose of our experiment, which took place on the ELFIE Laser at LULI in May and June this year, was to further understand the details of absorption in nanowires, and to study the high energy-density conditions created by the more energetic laser (~ 10 J on target). We also sought to investigate the response of nanowire targets to the higher energy laser, compared with traditional flat foil targets. We present a summary of our experiment, including diagnostic descriptions, and discuss some preliminary results.

References

[1] G. Kulcsar et al., Physical review letters **84**, 5149 (2000).

[2] M. A. Purvis et al., Nature Photonics **7**, 796 (2013).

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Field Enhancement of Multiphoton Induced Luminescence Processes in ZnO Nanorods

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We report studies of near-ultraviolet photoluminescence from ZnO nanorods excited by multiphoton absorption from unamplified femtosecond Ti:sapphire pulses. Measurements of the power dependence have been made using an adapted version of the interferometric frequency resolved optical gating method of ultrashort pulse characterization. These data enable separation of second harmonic and photoluminescence bands because of their different coherence properties. Our analysis yields power dependence exponents with fractional values between 3 and 4, which indicate the involvement of a number of nonlinear processes. The range of the exponents measured is attributed to variations in local field enhancement between samples, and this has been independently verified using photoluminescence and morphological measurements. Keldysh theory simulations show that three- and four-photon absorption processes, as well as avalanche ionization, contribute, in agreement with our experimental data.

Application of the femtosecond multi-frame interferometry in research on PALS facility, related to shock ignition concept of inertial fusion.

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Shock ignition (SI) approach belongs currently to the most promising concepts of target ignition in inertial confinement fusion (ICF). One of the main research aims related to the SI is the investigation of mechanisms for the ablation pressure generation due to various irradiation conditions of thermonuclear targets. To achieve the sufficiently high ablation pressure anticipated in the SI concept, a significant part of the absorbed laser energy is to be converted to fast electrons under the presence of pre-plasma. From the point of view of the SI-related research, particularly interesting is the initial phase of the expansion related to the interaction of the laser pulse with the ablative plasma in which processes of anomalous absorption responsible for the generation of fast electrons occur.
For these reasons to study the early phase of the plasma expansion the 3-frame interferometric system irradiated by the Ti:Sa femtosecond laser with a sufficiently short diagnostic pulse (~40 fs), operating at a wavelength of 808 nm has been used in research on PALS related to SI concept.
To imitate the SI conditions the 1ω beam with relatively low intensity (about 10^{13} W/cm^2) created a pre-plasma which simulates a compressed plasma in a real ICF experiment, while the second 1ω or 3ω laser beam (temporarily delayed with respect to the first one), with intensity higher than 10^{15} W/cm^2, generates an igniting shock wave in accordance with the SI concept. The experiments were performed using the special two-layer targets, which were irradiated at different beam intensities, controlled by varying the beam focal spot radius.
In case of the 1ω of laser beam, femtosecond interferometry decisively confirmed domination of resonant mechanism of fast electron generation and their contribution in a process of laser radiation transport to a shockwave in case of maximal intensity of laser beam, obtained for the minimum radius. However, pre-plasma created in two-beam experiments simulating SI concept conditions, significantly aggravate scalelength and electron density gradient, decreasing contributions of fast electrons to a shockwave.
In case of shorter wavelength (3ω) both femtosecond interferometry and measurements of crater formation efficiency clearly demonstrate influence of 1D expansion of plasma on laser energy transport to a shockwave. Axial character of expansion of plasma stream increases with increasing of laser beam radius, forcing higher ablative pressure. In contrast to 1st harmonic pre-plasma has a little effect on the transport of laser energy to a shockwave. Bremsstrahlung remains a dominant mechanism of radiation absorption. However, the temporal changes of scalelength and maximum gradient of electron density of ablative plasma, do not exclude other absorption mechanisms such as stimulated Raman scattering and two-plasmon decay.
Spectroscopic measurements of ablative plasma, including 2D imaging of K_α line from Cu, measurements of ion emission distributions carried out with mesh collectors and the crater creation efficiency measurements were an important supplement to information about processes of laser radiation energy transport by fast electrons, obtained by femtosecond interferometry.
The 2D simulations based on application of the ALANT-HE code and an analytical model that includes generation and transport of hot electrons has been used to support of experimental data.

The research was carried out in the framework of project LASERLAB: PALS-1914 (by T. Pisarczyk)

Comprehensive investigation of ablative plasma with using femtosecond polaro-interferometry for applications in inertial confinement fusion and astrophysics

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In the context of the current concept of inertial confinement fusion (ICF), the most important of which are**:** (i) fast ignition (FI) and (ii) shock ignition (SI), the knowledge about the spontaneous magnetic fields (SMF) distributions, generated in a compressed plasma and their influence on the fast electron emission is necessary for implementation of these concepts. Long-term studies, both experimental and theoretical, show that different mechanisms are responsible for the SMF generation, which depend on the plasma ablative parameters created for different irradiation conditions of the targets. These studies show that SPMs above 1MGs can significantly change the plasma transport coefficients and thus have influence on the electron density and temperature distributions of the plasma, the laser radiation absorption and reduce the plasma ablation pressure. For this reason, the SMF studies of laser plasma are still actual and important and therefore have been taken on the PALS experiments within LaserLab projects.
For these studies two-channel polaro-interferometer, irradiated by the Ti:Sa laser pulse with wavelength of 808 nm and duration of about 40 fs, is used. This diagnostics system allows to obtain information about SMF in two ways: (i) on the basis of the registration of the interferogram and polarogram and their analyze or (ii) based on the complex interferogram.
As a first stage of these investigations measurements of the SMF and electron density distributions were performed, for the different irradiation conditions of targets, by means of the 2-channel polaro-interferometer. Targets made of Cu, Al and plastic were irradiated with 1ω linearly and circular polarized laser beam with energy in range of 200-600 J and at minimal focus spot radius. Obtained SMF and density distributions enabled determination of current density, deposited energy in SFM and average electron energy distributions during laser pulse interaction with targets. It results from these measurements that the main part of the current (related to fast electrons) flows within a narrow cylinder with diameter of ≈ 130 μm which contains only 1.5-5 % of the total electron number. These fast electron currents may effectively magnetize ablative plasma, which in turn collimate the fast electron flow. The detailed understanding of these effects may help to produce jets of magnetized plasma with desired characteristics, optimize capacitor-coil targets, generate tailored fluxes of fast electrons or contribute to development of particle laser-based acceleration schemes.
For this reason, in the second phase of the project, the subject of polaro-interferometric studies are magnetized plasma streams produced by means of special-construction targets: (i) the snail-shaped cylinder targets and (ii) "open book" targets. The important aim of these investigation is to demonstrate a principal possibility to introduce laser plasma magnetization as a new controlled parameter in laboratory astrophysics. Preliminary results of these studies, obtained in the option of complex interferometry, are presented.

The research was carried out in the framework of LASERLAB projects: PALS-2117 and PALS-2200 (by T. Pisarczyk).

Novel Therapeutic Agents: Metal Carbonyl Complexes

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A series of novel fluorescent BODIPY/porphyrin metal (Cr/W) carbonyl complexes have been synthesised and their ability to release CO using visible light has been investigated. Cytotoxic evaluation of these novel CORM was assessed, with some CORMs demonstrating toxicity towards pancreatic cancer cells while controls demonstrated no cellular cytotoxicity. Internalisation of the CORMs into mammalian cells was verified using confocal microscopy with a higher level of fluorescence observed following irradiation, which indicates loss of CO within the cells. To date there have been few examples of luminescent CORMs demonstrating cellular uptake. Time resolved IR spectroscopy has allowed us to probe the excited state pathway leading to CO-loss in these complexes.

The role of molecular vibrations in photosynthetic light harvesting

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Photosynthesis in plants and bacteria is one the most studied processes in spectroscopy and structural biology, owing to its relatively high efficiency of converting light into chemical energy. Despite the concentrated research effort, many questions remain concerning the exact mechanism of key steps in the process. The first of these steps is the capturing of light by *light harvesting complexes* and directing the excitation to the *reaction center*. Finding a satisfactory description of these early steps in the photosynthetic process is the focus of our research, based on femtosecond spectroscopy and modelling. The presentation will introduce the chromophores and their structural arrangement before discussing our efforts to understand the underlying photophysics. In particular, we discuss the role of molecular vibrations in the context of efficient excited state energy transfer.

Single Plane Illumination Microscopy to study calcium oscillations in growing *Arabidopsis* root hairs

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Root hairs cover the primary root in multiple plant species, and drastically enlarge the root's absorption area for nutrient acquisition, water uptake and interaction with soil microbiota [1]. Root hair development is a highly dynamic process which requires tight control of spatial and temporal calcium concentrations at the subcellular level [3]. At the very tip of growing root hairs rapid oscillations in cytosolic calcium concentrations govern cell growth [2]. Distinct oscillatory calcium regimes relate to distinct oscillatory growth regimes. More so, transient calcium signalling events are ubiquitously present throughout plant development [4]. Hence, the ability to visualize subcellular calcium dynamics *in vivo* during prolonged time intervals at a high spatial/temporal resolution is crucial to better understand the fundamentals of calcium signalling in root hair and plant morphogenesis. The use of a genetically encoded calcium sensor (NES-YC3.6) allows for Förster Resonance Energy Transfer (FRET)/fluorescence-based visualization of cytosolic calcium concentrations [5]. A Single Plane Illumination Microscope (SPIM) setup was specifically designed in the lab of Prof. Bassi (CUSBO facility) to allow for long term acquisition of *in vivo* calcium gradients in the roots of upright growing *Arabidopsis* seedlings [6]. SPIM offers fast FRET-imaging and Z-stack image collection of a large root area, while resulting in minimal sensor bleaching and plant stress, thereby surpassing the capabilities of conventional fluorescence confocal microscopy techniques. We visualized apical cytosolic calcium oscillations in growing *Arabidopsis* root hairs of wildtype and *maia* (-/-) mutant plants. *Maia* plants lack a functional receptor-like kinase protein, leading to slow and irregular root hair elongation. Analysis of SPIM-output allowed us to show that *maia* root hairs, contrary to previous belief, did form an apical calcium gradient. Like wildtype plants, mutant root hairs displayed regular oscillatory behaviour in phase with growth, yet at a drastically lower frequency. Our data provide insight in how calcium dynamics regulate cell growth, and display the capabilities of SPIM-microscopy for high resolution *in vivo* imaging.

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Infrared Action Spectroscopy of Low-Temperature Nonaromatic Peptides in Gas Phase

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Proteins are building blocks of life that perform biologically crucial functions such as coordination of biological processes, energy and charge transfer, molecule transport, regulating speeds of chemical reactions *etc*. Proteins are polymers of amino acids connected by peptide bonds. The function a protein performs is determined by the conformation the polymer assumes upon folding. Structural analysis of protein conformations at atomic level is not only of fundamental importance but also relevant to developing efficient treatments for human diseases caused by misfolding of proteins. The initial step in the protein folding is formation of local secondary structures which are stabilized by intra-molecular hydrogen bonding. Conformations associated with formation of secondary structures can also be studied in small size amino acid polymers, such as peptides. The advantages of studying peptides are that they can be delivered to the gas phase, which enables nearly perfect isolation of a molecule, and that they are amenable, due to their limited size, to sophisticated theoretical calculations.

Infrared (IR) spectroscopy combined with quantum-chemical calculations are an efficient tool for conformational analysis of gas-phase peptides. The FELIX facility at Radboud University Nijmegen, the Netherlands, comprising three IR free electron lasers, provides a unique opportunity to perform IR spectroscopy of low-temperature gas-phase molecules. Traditional methods to measure IR spectra of neutral molecules in supersonic flow are generally applicable only to aromatic samples (*i.e.*, molecules possessing UV light absorbing chromophores), which significantly limits the scope of the systems to be studied. We have recently demonstrated a novel approach to measure IR spectra of chromophore-free neutral gas-phase molecules internally cooled in supersonic expansions. In this approach, the molecule is resonantly excited to a dissociative state by absorbing several IR photons. Dissociation products are then ionized with VUV photons and mass analyzed with an ion time-of-flight spectrometer. IR spectra are recorded by monitoring the intensity of the fragment signals while scanning the IR wavelength. In this talk I will present this new method in details, discuss its advantages and disadvantages, and will show examples of IR spectra for chromophore-free peptides: di-peptides, Gly-Gly and Ala-Ala; and penta-peptide, Ala-Ala-Ala-Ala-Ala. I will also present tentative theoretical assignments of the IR spectral features based on which we have inferred possible populated conformations.

PROTON IRRADIATION OF HUMAN CELL LINES AT ULTRAHIGH DOSE RATES

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A significant progress in technology has undoubtedly influenced radiation oncology, and today, a new frontier in radiation therapy for the treatment of localised tumors is represented by the hadrontherapy, which makes use of protons and ions beams. The advantages of hadrontherapy compared to traditional radiotherapy are rather relevant for many aspects. The most peculiar characteristic is the selective release of energy inside the body, which is done targeting only cancer cells; the damage incurred by the healthy cells of the body on initial penetration is relatively small and significant release of energy is confined only to the vicinity where the cancer is located (a phenomenon referred to as the Bragg Peak). Unfortunately, the very high cost of those machines, which are based on conventional accelerators, makes practically inaccessible the implementation of the hadrontherapy in the hospitals, limiting the spread and the use of this therapy in comparison to the conventional radiation therapy. The ability of high-power lasers to generate these ion beams and their relatively lesser cost have justified the research on laser-based ion acceleration for radiobiology. Preliminary work has been carried out in the last few years by a number of research groups on the methodology and feasibility of using laser-driven sources for cell irradiation experiments. At present, our group has preformed a number of experiments devoted to define a procedure for cell handling, irradiation and dosimetry using laser-driven ion beam; and additionally to investigate the radiobilogical effectiveness of ultra-high dose rates.
In this work, Human skin fibroblasts (AG01522 cells) and human vein endothelial cells (HUVECs) cells were exposed to 10MeV proton at dose rates exceeding 10^9-10^{10}Gy/s. DNA damage and repair was studied at specific time points and stress induced premature senescence (SIPS) was studied up to five weeks post exposure. A clonogenic assay was used to quantify cell killing efficiency of laser-accelerated protons in both cell lines. We observed a close similarity between the induced DNA DSB damage and SIPS for laser accelerated and conventional clinical proton beams and both showed enhanced effectiveness compared to low LET radiation (225 kVp X-rays). A strong reduction in cell survival was observed in cells irradiated with laser-driven ion beams compared to X-rays.
This is an important result to be considered in the eventuality of employing laser driven proton for cancer treatment, and for the optimization of tumour cell killing models.

Potential inhibition effect of Aβ_{1-42} self-aggregation kinetics

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Alzheimer´s disease (AD) is a progressive neurodegenerative disorder which affects brain and is defined by a progressive memory loss. It is a chronic-progressive disease based on the degenerative changes associated with neuronal death and formation of characteristic histopathological changes. One of the most considerable hallmarks of AD is the disruption of cellular amyloid metabolism resulting in the progressive accumulation of soluble neurotoxic Aβ-species that corresponds to Aβ_{1-42} [1]. Self-aggregation of Aβ_{1-42} monomers is a comprehensive process involving the production of different intermediates – oligomers, protofibrils, fibrils, but the detailed pathological mechanism is not fully understood [2, 3]. The focus of several studies was to evaluate aggregation modulators and/ or inhibitors in order to understand not only the kinetics of amyloid aggregation but also mechanism of disease formation and by that to find a potential effective therapy of Aβ assembly [4].

This project was focused on the study of Aβ_{1-42} via intrinsic fluorescence, its self-aggregation process *in vitro* involving investigation of appropriate working conditions (peptide concentration, % DMSO, time, temperature). Assay conditioning was followed by a detection of the influence of potential newly sythetized inhibitors (*K1068* and *K1081*) in comparison with standard inhibitor myricetin on the fibril kinetic formation using steady-state fluorescence and microscopy techniques. The observed results were then compared with routinelly used thioflavin T based fluorescence spectroscopy. It was determined that the intrinsic fluorescence of Aβ_{1-42} increases with the aggregation time until 33h and curves of Aβ_{1-42} self-aggregation were characterized by sigmoidal growth starting with lag-phase, fibril growth process and final plateau. Scattering measurements indicated that myricetin and compound *K1081* behave as effective inhibitors of Aβ_{1-42} self-aggregation what was also confirmed with confocal microscopy at the same conditions.

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Femtosecond laser micromachining of a cell cultivation membrane in photosensitive glass

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Abstract

The use of thin porous membranes in microfluidic systems is crucial for many applications, as they can be applied for separation and filtration purposes. The fabrication and integration of such a membrane in a microfluidic system by assembly and by thin film deposition using lithographic fabrication processes is in most cases complex, due to the filigree structure of the membrane. The main objective of the Laser lab visit was the fabrication of a three-dimensional *in vitro* system for the cultivation of cerebral-vascular cells, in order to mimic the Blood-Brain-Barrier [1]. These so called Organ-on-a-Chip systems are miniaturized models of organs, which can be used to perform pharmaceutical studies under more relevant conditions. Commercially available well-plate-based cell cultivation membranes are commonly made of polymers and allow only cultivation under static conditions. Microtechnological approaches for 3D cell culture models often use Polydimethylsiloxane (PDMS) for the fabrication of microfluidic systems. The drawbacks of PDMS, such as the absorbance of active substances and dyes, make the application for pharmaceutical-technical analysis doubtful. Fused silica on the other hand exhibits adequate material properties concerning the biological and chemical compatibility of the material. Furthermore, the refractive index and the etching susceptibility can be modified by femtosecond micromachining [2].

Experimental procedure

Here, we present a monolithic fabrication approach, introducing a thin porous membrane inside a microfluidic system, separating two above lying microchannel. Thereby, different methods and micromachining strategies had been carried out and evaluated in order to identify the ideal interplay of micromachining parameters and etching process. The laser irradiation experiments at the Laser Research Center in Vilnius have been performed with a femtosecond laser (Light Conversion), 20W model (Pharos), with 1026nm wavelength, 260 fs pulse duration at a frequency of 610 kHz.

First, the focus was set on the fabrication of a porous membrane with a thickness below 10 µm and a pore size smaller than 1 µm. To identify the proper irradiation parameter and an optimal laser-writing strategy, concerning the polarization of the beam, a set of sliced squares had been written into a bulk fused silica slide (JGS 3 type). The variation of the pulse energy in combination with different stage velocities, have shown promising results at 350 nJ and 5,5 mm/s. After micromachining the samples were chemically wet etched in hydrofluoric acid with a 2,5% and a 40% concentration. During the etching process, an irregular etching face was observed, resulting in a displacement and a deformation of the membrane. In order to realize a uniform controlled etching face from both sites of the membrane, the laser writing orientation as well as the polarization needed to be adapted. Further, single pulses were introduced inside the membrane to create pores during the etching process. Due to the longitudinal ellipsoidal shape of the focal point the membrane thickness needed to be varied according to the applied energy pulses.

The obtained results were used for the fabrication of the second configuration, consisting of two microfluidic channels and the membrane. In a similar way, as above mentioned, four rectangular shaped vertical microfluidic channel were written into the sample. To realize a controlled etching face, during wet chemical etching, several straight lines, in a V-shape were written between the two vertical microfluidic channel, as illustrated in figure A. Also, for a more selective etching process potassium hydroxide KOH (40% concentration at 80°C) had been applied. Figure B shows the two microfluidic channels after 18 h wet chemical etching in KOH. After 36 h the microchannel were etched though, leaving a thin porous membrane in between with a thickness of 6 µm.

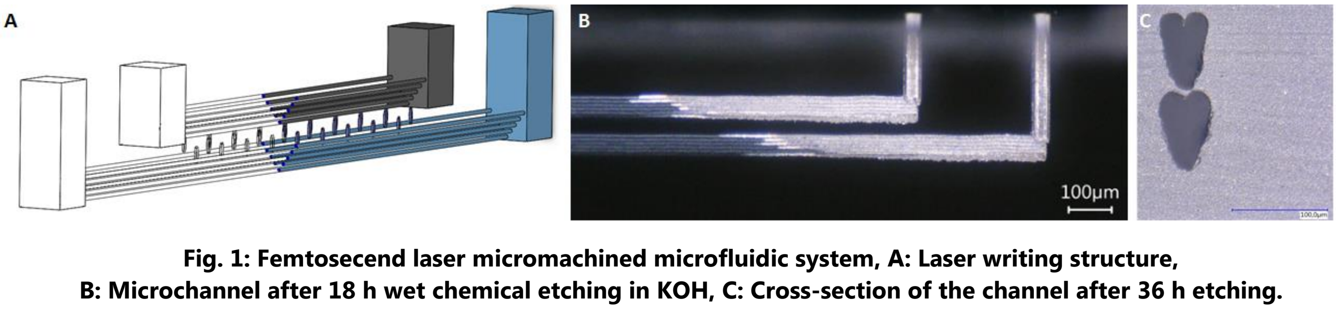

Fig. 1: Femtosecend laser micromachined microfluidic system, A: Laser writing structure, B: Microchannel after 18 h wet chemical etching in KOH, C: Cross-section of the channel after 36 h etching.

Acknowledgements

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Optical coherence tomography and non-linear microscopy for paintings – a study of the complementary capabilities and laser degradation effects

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This paper examines for the first time the potential complementary imaging capabilities of Optical Coherence Tomography (OCT) and Non-linear Microscopy (NLM) for multi-modal 3D examination of paintings following the successful application of OCT to the in situ, non-invasive examination of varnish and paint stratigraphy of historic paintings and the promising initial studies of NLM of varnish samples. OCT provides image contrast through the optical scattering and absorption properties of materials, while NLM provides molecular information through multi-photon fluorescence and higher harmonics generation (second and third harmonic generation). OCT is well-established in the in situ non-invasive imaging of the stratigraphy of varnish and paint layers. While NLM examination of transparent samples such as fresh varnish and some transparent paints showed promising results, the ultimate use of NLM on paintings is limited owing to the laser degradation effects caused by the high peak intensity of the laser source necessary for the generation of non-linear phenomena. The high intensity normally employed in NLM is found to be damaging to all non-transparent painting materials from slightly scattering degraded varnish to slightly absorbing paint at the wavelength of the laser excitation source. The results of this paper is potentially applicable to a wide range of materials given the diversity of the materials encountered in paintings (e.g. minerals, plants, insects, oil, egg, synthetic and natural varnish).

The spectroscopic analysis of pigments of wall paintings from archeological findings on territory of Russia and former Soviet Union

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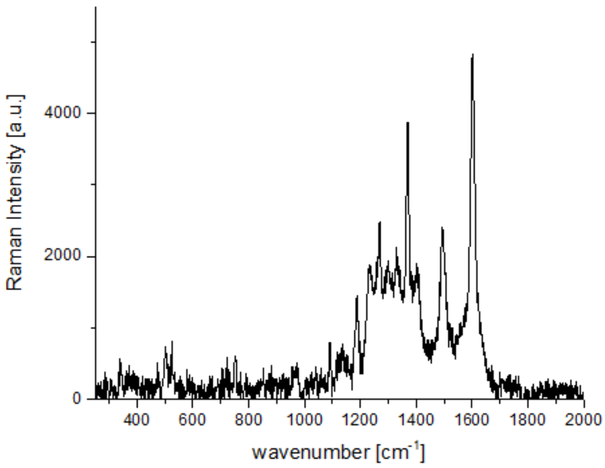
Our project (#LENS 002163) was aimed onto experimental study of a group of ancient painting samples from archaeological findings on territory of Russia and former Soviet Union. These studies have been conducted by means of spectroscopic techniques, which are available at the LENS laboratory. Four sets of samples have been studied. One part of samples was set of fragments of wall paintings, which have been collected during archaeological excavation works in the beginning of XX century on territory of ancient cities Panjikent and Turfan located along the Silk Road on territory of modern state Tajikistan. Second part of samples is set of fragments of rock paintings collected from a number of archaeological sites in Russia including Kapova cave and the open-air Upper Paleolithic site of Zaraysk. Third part of samples are fragments of wall paintings from one of the Russian Orthodox churches of the ancient town Dovmontov, which was located near territory of Pskov Kremlin (Russian North West, southeast from St.Petersburg). One more set of samples are fragments of wall paintings of XVIII century, which have been recently found in one of oldest palaces of St.Petersburg.



The main goal of our research work was the determination and comparison of the composition of pigments from different archaeological sites. We paid a special attention to study of the coloring materials used as pigments and to search for organic substances, probably employed as binders. Most of experiments have been carried out using micro-Raman technique, but in some cases we have used FTIR spectroscopy. The experimental results, which are concerned with samples from ancient city Turfan, are most interesting, because we have found that they contain pigment of bright green color. Though such pigments are very rare for ancient South Asia wall paintings of that period (our samples are dated back to about V-VIII A.C.), but in scientific literature one can find information about such pigments in fragments of some wall paintings from some archaeological sites in the Silk Road region [1]. Another interesting experimental result, which is also connected with the Turfan`s sample, is finding the pigment gamboge dye (from the part with brown appearance) (see its Raman spectrum in the Figure). It is a yellow vegetable pigment produced in south and southeast Asia from various trees (it is a gum resin). Investigation has implied that gamboges was used on a Tang dynasty painting from Turfan in Xinjiang province, China (seventh to ninth century).

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Strong electromagnetic pulses generated in high-intensity fs laser interaction with thin foil targets

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Abstract

Measurements are reported of the target neutralization current, the target charge for the laser energies, and the tangential component of the magnetic field generated by pulses with the energy in the range of 45 mJ to 92 mJ and laser pulse durations from 39 fs to 1000 fs. Experiment was performed at the Eclipse facility in CELIA, Bordeaux. The idea of the experiment was to extend investigations performed for the thick (mm scale) targets to the case of thin (µm thickness) targets in a way that would allow for a straightforward comparison of the results. We found that thin foil targets tend to generate 30%-50% higher neutralization current and the target charge. We also measured the tangential component of the magnetic field for the EMP generated at various laser conditions and various targets. We found that the EMP is in general consistent with the dipole antenna model, with 1 GHz dominant frequency, consistent with the behavior of the neutralization current, although we noticed that the initial spikes have a characteristic sub-ns structure which depends on the target type and which appears to be reproducible to a surprizing degree.

Amplification of solid laser harmonics in resonant nanostructures

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A scheme is proposed for high harmonic generation (HHG) in crystals using nanoscale amplification of a mid-infrared laser. While resonant plasmonic amplification has been applied to multiple nonlinear optics processes (like second harmonic generation), the extension to HHG has been hampered by two main factors. First the low damage threshold of metallic nanoparticles at IR and mid-IR wavelengths. Second, a difficulty in designing appropriate large amplifying volume resonant structures. Indeed, the bowtie geometry that has been mostly used up to now, while offering a very high localized field enhancement presents nm^3 scale volume**.**

Here, we introduce a novel structure which solves these issues while efficiently amplifying the harmonic signal. We use zinc-oxide nanocones to enhance locally the electric field through waveguiding effect rather than plasmonic resonance. Our semiconductor nano-structures exhibit a large and homogeneous amplifying volume, at least 6 orders of magnitude larger than previously reported and avoid melting observed at high laser intensities in metallic plasmonic structures. We report the experimental observation of a strong amplification of solid harmonics pumped at modest laser intensities of few 10^{11}W/cm^2. Direct imaging of the harmonic nano-emitters allows for the determination of the local amplification factor which strongly depends on the nanocones quality. Local amplification up to a factor of 500 to 10 is measured for the 7th to the 15th harmonic respectively from the nanocones with respect to the bare crystal[1].

Our results open the way towards HHG and strong field physics at high repetition rates with low cost small scale femtosecond lasers (oscillators, fibre lasers). Potential applications range from nanoscale imaging, efficient storage and transfer of information to nanoplasmonics, novel photon and particle sources, and even biomedical sciences.

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