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PROGRAMME AND ABSTRACTS

LASERLAB USER MEETING

16-17th February 2012
University of Szeged
HUNGARY

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LASERLAB USER MEETING

"From quantum electronics towards medicine and particle physics"

16-17th February 2012

University of Szeged

Location:

Building of the Hungarian Academy of Sciences (SZAB)

Somogyi u. 7. Szeged, Hungary

Organizer

Sándor Szatmári

University of Szeged, Department of Experimental Physics

Chairs

István Földes

Wigner Research Center of the HAS Institute for Particle and Nuclear Physics, Budapest, Hungary

Oldrich Renner

Institute of Physics, v.v.i. Academy of Sciences CR, Prague, Czech Republic

THURSDAY, FEBRUARY 16th

08:30-12:00 **Registration**

09:00-09:10 **Opening by Organizer and Meeting Chairs**

09:10-09:20 **Welcome by the Rector of the University of Szeged**

Session 1.
Hot dense plasma diagnosis and emission characteristics
Chair: István Földes, Budapest, Hungary

09:30-10:00 **Recent investigations of laser-produced plasma jet formation and laser driven macroparticle acceleration for ICF and laboratory astrophysics applications,** Tomasz Chodukowski, Institute of Plasma Physics and Laser Microfusion, Poland

10:00-10:30 **Diagnostic of Hot Dense Plasmas by Advanced X-ray Spectroscopy,** Ingo Uschmann, Jena University, Germany

10:30-11:00 **Conversion efficiency measurement of relativistic harmonics,** Angéla Barna, University of Szeged, Hungary

11:00-11:30 **COFFEE BREAK**

11:30-12:00 **Laser-driven cylindrical compression of targets for fast electron transport study in warm and dense plasmas,** Luca Volpe, University of Milano Bicocca, Italy

12:00-12:30 **Equilibrium charge state distribution measurement in warm dense matter,** Maxence Gauthier, Laboratoire pour l'Utilisation des Lasers Intenses, Palaiseau, France

12:30-13:00 **Femtosecond Stimulated Resonance Raman (FSRRS) spectroscopy** Sophia Hayes, University of Cyprus

13:00-14:30 **BUFFET LUNCH**

Session 2.
Advanced plasma applications
Chair: Oldrich Renner, Prague, Czech Republic

14:30-15:00	**Ultrafast, coherent dynamics of biomimetic molecular switches,** Jérémie Léonard, IPCMS-Université de Strasbourg, France
15:00-15:30	**Gating of high-order harmonics emission by incommensurate two-color mid-IR laser pulses,** Valer Tosa, National Institute for R&D Isotopic and Molecular Technolgies, Cluj-Napoca, Romania
15:30-16:00	**Experimental results in shock ignition experiments at Pals: K-Alpha and shock waves generation**, Luca Antonelli, University of Rome "Tor Vergata", Italy ***(to be presented by Luca Volpe)***
16:00-16:15	**COFFEE BREAK**
16:15-16:45	**Employing nonlinear imaging microscopy for characterization of microlenses produced in different biocompatible materials,** Aleksandar Krmpot, Institute of physics, University of Belgrade, Belgrade, Serbia
16:45-17:15	**GeV electron acceleration experiment at Astra-Gemini,** Nelson Lopes, Grupo de Lasers e Plasmas, IPFN, Instituto Superior Técnico, Lisboa, Portugal
17:15-17:45	**Overview of Laserlab Europe User training activities,** Dusan Chorvat, International Laser Centre, Bratislava, Slovakia
19:30 -	**GALA DINNER**

FRIDAY, FEBRUARY 17th

08:00-08:30 **ELI-ALPS, the attosecond ELI facility in Szeged,** Károly Osvay, University of Szeged, Hungary

08:30-11:00 **ACCESS BOARD MEETING**

Session 3.
Particles and radiative sources
Chair: Károly Osvay, Szeged, Hungary

08:30-09:00 **Laser ablation produced nanoparticles for cancer diagnostics and therapy,** Alexandre (Sasha) Douplik, Erlangen University, Germany

09:00-09:30 **Nonlinear excitation of tailored nanostructures (NEXT),** Frank Güell, Universitat de Barcelona, Spain

09:30-10:00 **Electron beam and X-ray radiation generated by laser wake field in dielectric capillary tubes,** Jinchuan Ju, Universite Paris-Sud 11, France

10:00-10:30 **Towards a laser based compact magnetic fusion device,** Stavros Moustaizis, Technical University of Crete, Science Department, Crete, Greece

10:30-11:00 **COFFEE BREAK**

11:00-12:00 **ROUND TABLE discussion "Towards Laserlab 3"**

chaired by Didier Normand

12:00 **CLOSING REMARKS, END OF MEETING**

12:30-13:30 **OPTIONAL VISITS TO LASER LABORATORIES OF THE UNIVERSITY OF SZEGED**

ABSTRACTS

Recent Investigations of laser-produced plasma jet formation and laser driven macroparticle acceleration for ICF and laboratory astrophysics applications

Tomasz Chodukowski

Institute of Plasma Physics and Laser Microfusion, Poland

In 2011 the investigates concerning generation of plasma streams and macroparticles acceleration for an execution of Inertial Confinement Fusion (ICF) as well as for laboratory astrophysics were carried out at Prague Asterix Laser System (PALS) within LaserLab framework (PALS-001552, PALS-001514) by the team from Institute of Plasma Physics and Laser Microfusion.

In experiments related to the PALS-001552 project new methods of generation of narrow plasma streams (jets) from targets of different geometry (ring, channel, cone and cone with pressure cavity), made of different materials, were proposed and realized. On the basis of the project [1], a possibility of compressing by a light plasma of heavier plasmas so as to obtain the plasma jets with better parameters was also tested. Using targets made of materials with low and high atomic numbers (combinations of plastic-Cu and plastic-Al) we revealed possibility of obtaining of plasma streams from Cu and Al targets with better parameters (smaller diameter, higher electron density and velocity) and also obtaining of plasma streams with pipe- and cone-like configurations, interesting for astrophysical applications.

For visualization of plasma expansion there were a 3-frame interferometric system used, irradiated by second harmonic of PALS laser, and a 4-frame pinhole camera recording images in the soft X-ray range of 10-1000 eV.

In of the second project frames (PALS-001514) we carried out studies concerning ultra-intensive laser-plasma interactions and studies related to Shock Ignition as an option to laser thermonuclear fusion. We continued experimental and numerical researches of hydrodynamic LICPA accelerator [2]. In shock ignition studies, influence of pre-plasma on laser-generated shock wave parameters were investigated. The investigations were focused on the determination of global characteristics of the shock (total energy, pressure) as a function of the preformed plasma characteristics, controlled by the delay Δt between the auxiliary beam (1ω, 5×10^{13}W/cm^2) and the main 3ω laser pulse of intensity ~ 10^{16} W/cm^2.

Characteristics of plasma ablated from the plastic target were measured with the use of 3-frame interferometry, ion diagnostics (several ion collectors, Thomson spectrometer),an X-ray spectrometer, and Kα imaging. Results of the studies mentioned above are currently analysed and developed.

[1] T. Pisarczyk, A. Kasperczuk, M. Kalal, S. S. Yu. Guskov, J. Ullschmied, E. Krousky, K. Masek, M. Pfeifer, K.Rohlena, J. Skala, and P. Pisarczyk : *Characteristics of the plasma jet generated from a joint of materials with different atomic number.* 35th EPS Conference on Plasma Phys. Hersonissos, 9- 13 June 2008, ECA **Vol. 32,** P- 1.118 (2008).

[2] J. Badziak, S. Borodziuk, T. Pisarczyk, T. Chodukowski, E. Krousky, K. Masek, J. Skala, J. Ullschmied, and Yong-Joo Rhee, *Highly efficient acceleration and collimation of high-density plasma using laser-induced cavity pressure*, Appl. Phys. Lett. **96**, 251502 (2010).

Diagnostic of Hot Dense Plasmas by Advanced X-ray Spectroscopy

I. Uschmann

Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany

Hot and dense plasmas are currently investigated for their importance both as ultrashort, bright XUV and x-ray sources and as a medium for Inertial Confinement Fusion.

The development of high intensity- and high power laser systems as well as short wavelength Free-Electron Lasers provide interaction of laser radiation with matter delivering plasmas with high temperatures and nearly solid density. Those plasmas are emitting intense x-ray emission resulting from recombination or interaction of the hot electrons and ions with solid matter. The analysis of the x-rays plays an important factor to study the laser matter interaction, fundamental plasma parameters such as density and temperature and their spatial gradients, as well as strong electromagnetic fields.

Bragg-reflection from perfect crystals with bent surface mirror allows to record space resolved keV x-ray emission in selected spectral ranges. High performance of the bent crystal surface as well as crystal treatment like polishing and edging are essential for high quality X-ray imaging as well as high spectral resolution combined with high luminosity. Spherically or toroidally bent crystals provide either two dimensionally images or focused x-ray spectra combined with a spatial resolution. Application of high-resolution x-ray spectroscopy will be presented to study energy coupling of fast electrons to solid density plasma providing complex information on environmental conditions in hot dense plasmas.

Conversion efficiency measurement of relativistic harmonics

A. Barna[1,2], P. Heissler[3], J.M. Mikhailova[3], K. Khrennikov[3], S. Karsch[3,4], L. Veisz[3], F. Krausz[3,4], G.D. Tsakiris[3] and I.B. Földes[1]

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[2]*University of Szeged, Szeged, Hungary*
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[4]*Fakultät für Physik, Ludwig-Maximilians-Universität München, D-85748 Garching, Germany*

Relativistic high harmonics were generated when laser pulses from the ATLAS laser system, having 28fs duration with a maximum energy of 2J were focused onto solid surfaces. The beam was focused by a 90° off-axis parabola mirror onto the fused silica targets. The harmonics were reflected by an Au mirror onto the entrance slit of a Hitachi flat-field grating spectrometer using a 150nm Al filter. The spatial distribution of the harmonics was measured (after removing the Au mirror) by an MCP detector of 75mm diameter. An absolute calibrated IRD AXUV diode – behind 1.25um Al filter - could be introduced into the beam in front of the MCP. The simultaneous observation of the diode signal with the spatial distribution of the harmonics enabled us to carry out absolute measurement of the conversion efficiency into harmonics.

High harmonics generated by the relativistic oscillating mirror (ROM) mechanism were observed. For the maximum available on-target laser energy of 300mJ harmonics were observed to propagate in a large solid angle probably due to preplasma caused by the high prepulse level of the beam which might have destroyed the planar phase front of the beam. The prepulse level was reduced by attenuating the laser beam. In case of energies between 72mJ and 100mJ collimated ROM harmonics appeared with the target in focus, thus showing that the contrast level – as well as the intensity - plays a very important role. This beaming effect with 20-30 mrad divergence of the harmonics was observed for a typical $a_L \cong 1.4$ intensity. The conversion efficiency was measured to be $\sim 10^{-4}$ to an average harmonics of ~44eV photon energy. By improving the contrast of the beam and thus further reducing preplasma effects one expects even higher conversion.

Laser-driven cylindrical compression of targets for fast electron transport study in warm and dense plasmas

Experiment performed in 2008 at RAL laboratory PI D. Batani and M.Konig

L. Volpe[1], B. Vauzour[2], Ph. Nicolai[2], J.J. Santos[2], F. Dorchies[2], C. Fourment[2], S. Hulin[2], C. Regan[2], F. Perez[3], S. Baton[3], K. Lancaster[4], M. Galimberti[4], R. Heathcote[4], M.Tolley[4], Ch.Spindloe[4], J. Pasley[4,13], A. Debayle[5], J. Honrubia[5], L. Gremillete[6] P. Koester[7], L. Labate[7], L.A. Gizzi[7], C. Benedetti[7], A. Sgattoni[8], M. Richetta[9], W. Nazarov[10] , F.N. Beg[11], S. Chawla[11,12], D.P. Higginson[11,12], A. G. MacPhee[12] and D. Batani[2] and M. Konig[3]

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[2]*Universite´ de Bordeaux-CNRS-CEA, Centre Lasers Intenses et Applications (CELIA), Talence, F-33405, France*
[3]*LULI, Ecole Polytechnique, CNRS, CEA, UPMC, 91128 Palaiseau Cedex, France*
[4]*Central Laser Facility, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[5]*ETSI Aerona´uticos, Universidad Polite´cnica de Madrid, Spain*
[6]*CEA, DAM, DIF, F-91297 Arpajon, France*
[7]*ILIL, Istituto Nazionale di Ottica, UOS Adriano Gozzini, CNR, Via G. Moruzzi 1, Pisa, Italy*
[8]*Dipartimento di Fisica, Universita` di Bologna, Bologna, Italy*
[9]*Dipartimento di Ingegneria Meccanica, Universita` di Roma Tor Vergata, Italy*
[10]*University of St. Andrews, Fife KY16 9AJ, Scotland, United Kingdom*
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[12]*Lawrence Livermore National Laboratory, Livermore, California 94550, USA*
[13]*York Plasma Institute, Department of Physics, University of York, York, YO10 5DQ, United Kingdom*

Fast ignition requires a precise knowledge of fast electron propagation in a dense hydrogen plasma. In this context, a dedicated HiPER (High Power laser Energy Research) experiment was performed on the VULCAN laser facility at the Rutherford Appleton Laboratory (UK) where the propagation of relativistic electron beams through cylindrically compressed plastic targets was studied. In this experiment a cylinder was compressed with ~200 J of laser light (1 ns λ=0.53 μm) in 4 symmetrically incident beams. The cylindrical target has been arranged by the Vulcan target area and it comprises a 200 μm-long polyimide cylindrical tube with 220 μm outer diameter and 20 μm wall thickness which in some cases is filled with a plastic foam (acrylate) at a density of either 0.1 g/cc or 1 g/cc. In the first phase of the experiment laser-driven protons and K alpha photons have been alternatively generate via the interaction between the Vulcan short pulse (10 ps, λ=1.06 μm) and a gold and copper foils to radiograph the imploding cylinder at different stage of compression. In this way we studied the compression degree and the stagnation time comparing the diagnostics results together with hydrodynamic and Monte Carlo simulations . In the second phase of the experiment the Vulcan short pulse was used to generate and accelerate fast electrons at the edge of the imploding cylinder. The electron beam transport into the imploding target has been studied comparing K-alpha emission together with a numerical transport code. The final results show that implosion-driven electrical resistivity gradients induce strong magnetic fields able to guide the electrons.

Equilibrium charge state distribution measurement in warm dense matter

M.Gauthier[1,2], S.N. Chen[1], A. Lévy[1], L. Romagnani[1], M. Cerchez[3], D. Doria[4], V. Floquet[5], C. Perth[3], T. Toncian[3], O.Willi[3], M. Borghesi[4], G. Faussurier[2], J. Fuchs[1]

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[3]Heinrich Heine Universität Düsseldorf, D-40225 Düsseldorf, Germany
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[5]Service des photons, atomes et molécules, Commissariat à l'énergie atomique, 91191 Gif-sur-Yvette, France

Equilibrium charge state distribution of ions after passing through cold solid target has been measured for many years. Nevertheless, far less is known in the warm dense regime where the ionization of matter is affected by heating it by external means. The difficulty of creating well-characterized, uniform warm plasmas has made such detailed measurements problematic up to now. We present a recent experiment performed on the 100TW ELFIE (LULI, Ecole Polytechnique) laser system. We measured, at several projectile energies, the charge-state distribution and equilibrium length of light and heavy ion beams after passing through either cold or isochorically-heated warm dense matter. The experimental details and first results from the campaign will be described.

Femtosecond Stimulated Raman Study of Excited State Reorganization in Organic Semiconductors

Sophia C. Hayes

Dept. of Chemistry, University of Cyprus

Understanding the ultrafast dynamics of the electronic excited states of π-conjugated polymers will enable manufacturers to synthesize more robust and energy efficient materials for the construction of organic solar cells and light emitting diodes. The presentation will introduce Femtosecond Stimulated Resonance Raman (FSRRS) spectroscopy and its utility in probing excited state dynamics. FSRRS is a powerful technique for following early-time (tens of femtoseconds) structural dynamics with mode-specific resolution of ~15 cm^{-1}. We will demonstrate how this method can be successfully applied in the study of a variety of chemical systems, including organic semiconductor materials, in order to answer fundamental questions in their photochemistry and photophysics.

Access to Central Laser Facility, STFC, Rutherford Appleton Laboratory, UK through the Laserlab 2 EC Grant Agreement No. is 228334 is gratefully acknowledged.

Ultrafast, coherent dynamics of biomimetic molecular switches

J. Léonard[1], D. Polli[2], G. Cerullo[2], M. Olivucci[3,4], S. Haacke[1]

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[2] *Centre for Ultrafast Science and Biomedical Optics, Politecnico di Milano, Italy*
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Photoisomerizing molecular switches based on the indanylidene-pyrroline (IP) chemical skeleton have been designed such that their excited state potential energy surface is similar to that of retinal in rhodopsin (Rho) [1,2]. As a result, the biomimetic molecules undergo an ultrafast photoisomerization involving a coherent vibrational dynamics through a conical intersection [3,4]. This is a rare biomimetic process in which light (electronic) energy is converted into mechanical (vibrational) energy localized in specific molecular modes. However, the photoisomerization quantum yield of the IP photoswitches does not exceed 35% while that of Rho reaches 66%. Hence the IP photoswitches appear as a model system to investigate the mechanism that govern the quantum yield of a photoreaction through a CI, and the putative role of vibrational coherence in that mechanism. Here we report on a preliminary comparison between the photoisomerization dynamics in three variants of the IP switches. Transient absorption spectroscopy is implemented with a sub 30-fs UV pump and a 7-fs VIS probe. In the 500-700 nm spectroscopic window, we observe successively the signature of the excited state (stimulated emission) followed by the impulsive onset of the photoproduct signature in only two out of three cases. Interestingly, the data indicate that chemical substitutions which do not affect significantly the electronic structure of the photoswitches do in turn affect markedly the excited state life time, and consequently, the coherence properties of the vibrational relaxation.

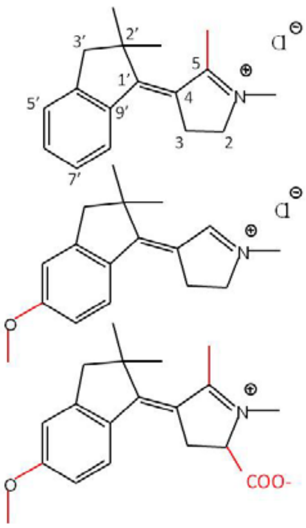

Figure: Structure of the three representatives of the IP molecular family investigated here, with the various chemical substitutions highlighted in red. Ultrafast photoisomerization occurs around the C4=C1’ double bond in the three cases, at different speeds.

References

[1] F. Lumento, V. Zanirato, S. Fusi, E. Busi, L. Latterini, F. Elisei, A. Sinicropi, T. Andruniów, N. Ferré, R. Basosi, and M. Olivucci. Angew. Chem., 119:418–424 (2007).
[2] A. Sinicropi, E. Martin, M. Ryasantsev, J. Helbing, J. Briand, D. Sharma, J. Léonard, S. Haacke, A. Canizzo, M. Chergui, V. Zanirato, S. Fusi, F. Santoro, R. Basosi, N. Ferré and M. Olivucci, Proc. Nat. Acad. Sci. USA105, p. 17642-17647 (2008).
[3] J. Briand, O. Bräm, J. Réhault, J. Léonard, A. Cannizzo, M. Chergui, V. Zanirato, M. Olivucci, J. Helbing and S. Haacke, Phys. Chem. Chem. Phys. 12, p.3178–3187 (2010).
[4] J. Léonard, I. Schapiro, J. Briand, S. Fusi, R. Rossi Paccani, M. Olivucci, S. Haacke, submitted.

Gating of high-order harmonics emission by incommensurate two-color mid-IR laser pulses

V. Tosa[1], K. Kovacs[1], M. Negro[2], C. Vozzi[2], S. De Silvestri[2], and S. Stagira[2]

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We explore the possibility to obtain single attosecond pulses from long (>30 fs) laser pulses by generating a temporal gate for the high order harmonics emission through a combined action of two midir fields having incommensurate frequencies. Experimentally we developed a set-up for the temporal overlap of two linearly polarized pulses coming from optical parametric amplifiers, at wavelengths of 1.35 and 1.75 μm, respectively. Numerical modeling [1] completes the investigation process by calculating the harmonic field developed in the interaction region by two mid-IR pulses of incommensurate frequencies. Parallel and perpendicular cases of the polarization directions were investigated.

Results obtained in xenon [2] show continuous spectra with a significant cutoff extension, from 50 to up to 75 eV. Modeling results obtained until now for xenon reproduce fairly the main experimental features, as one can see from Fig. 1. The analysis of harmonic field in time domain reveals the generation of single attosecond bursts by spatial filtering in the far field.

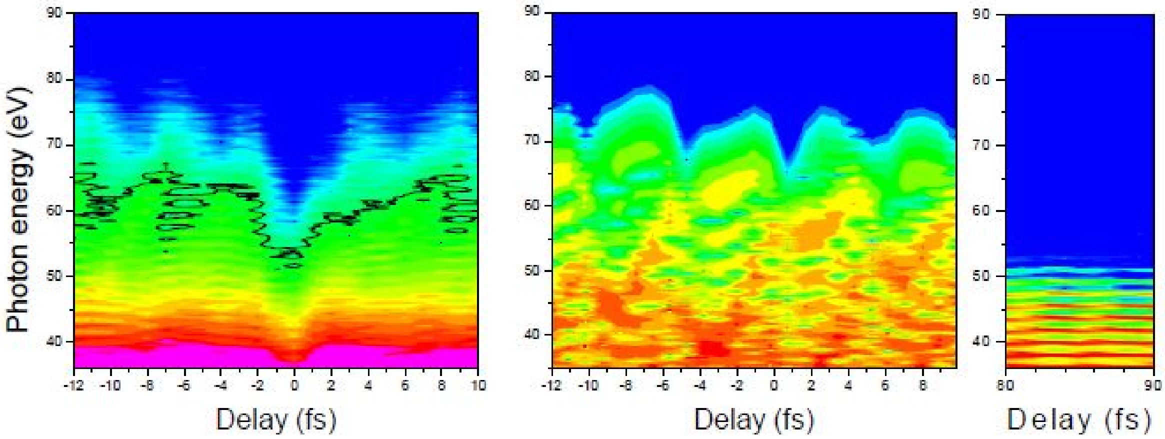

Figure 1. Experimental (left) and numerical (middle) spectra as a function of the delay between the two mid-IR pulses. The right panel shows the measured spectra at large delays with practically no pulse overlapping.

These outcomes demonstrate the possibility of extending the two-color gating technique for the generation of isolated attosecond bursts to a mid-infrared laser source and are, to our knowledge, the first experimental demonstration of the gating on laser pulses longer than 30 fs. The modeling confirms the formation of a single attosecond pulse as a combined effect of gating laser and harmonic field propagation in an ionized media and spatial filtering in the far field.

1. V. Tosa, C. Altucci, K. Kovacs, M. Negro, S. Stagira, C. Vozzi, and R. Velotta, *Isolated Attosecond Pulse Generation by Two-Mid-IR Laser Fields* IEEE J SEL TOPICS QUANT ELECTRONICS **18**, 239-247 (2012)

2. M. Negro, C. Vozzi, K. Kovacs, C. Altucci, R. Velotta, F. Frassetto, L. Poletto, P. Villoresi, S. De Silvestri, V. Tosa, S. Stagira, *Gating of high-order harmonics generated by incommensurate two-color mid-IR laser pulses* LASER PHYSICS LETTERS **8,** 875-879 (2011)

Experimental results in shock ignition
Experiments at PALS: K-alpha and shock waves generation

L. Antonelli[1], P. Koester[2], L. Labate[2], T. Levato[2], L. Gizzi[2], D. Batani[3], M. Richetta[1], E. Krousky[4], O. Renner[5], M. Smid[5], M. Rosinski[6], J. Badziak[6], T.Pisarczyk[6], Z. Kalinowska[6], T. Wodzu[6]

[1]*University of Rome "Tor Vergata", Rome, Italy*
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[6]*IPPLM, Warsaw, Poland*

Shock Ignition is a novel approach to Inertial Fusion Confinement proposed by Betti et al. in 2007, based on direct drive illumination and on the concept of a non isobaric fuel assembly obtained using two different laser pulses. A first compression phase (ns laser pulses at about 10^{14} W/cm^2) provides to the initial compression of the target. A second shock phase (sub-ns laser pulses at 10^{15} - 10^{16} W/cm2) is used to lunch a strong convergent shock wave and achieve the ignition conditions. On paper, this approach presents several advantages like a smaller amount of required laser energy with respect to the classical centralignition approach and the possibility to achieve higher gains. Also SI is compatible with present day (NIF-like) laser technology and it does relay on such exotic physics as using relativistic electrons as it is the case for the Fast Ignition approach.
Also, in SI, a low amount hot electrons could indeed be beneficial because they could help in improving the laser-target coupling without producing a substantial preheating (being produced by the strong shock spike at late times, when the target has already achieved a large (rho)R).
A study of shock wave generation and hot electrons production and penetration was made at Prague Asterix Laser System. In our experiment we used a planar geometry and two laser beams. The Iodine gas laser system has a fundamental wavelength of 1.3 μm, a pulse duration of about 300 ps and energy up to 1 KJ. We used a first laser pulse to simulate the compression phase. This pulse had an intensity of 10^{13} Watt/cm^2 at 1ω. A second laser pulse at 3ω with intensity of 10^{16} Watt/cm^2 was used to lunch a planar shock. The delay between the first and the second laser pulse was not fixed in order to study the laser plasma coupling and shock wave and hot electrons generation with a preplasma on the front side of the target. One-layer targets and Multilayer targets were used. One-layer targets were 30 μm of Cu. Multilayer targets had a first layer (25 μm) of plastic (Parylene C (C8H7Cl)) to simulate the low Z material of fusion target shell, producing a low Z plasma corona in front of the target, a second layer of Cu (5 μm) used to trace the hot electrons through k-alpha emission, and a third layer (20 μm) of Al used as shock reference (Al is a well known material in shock studies). Some targets had a step of 10 μm of Al to have a direct measurements of the shock velocity in the final stage. Experimental measurements were done with:

1) A streak Camera to register the shockwave breakout time
2) Imaging K-alpha crystal to have an image of the K-alpha emission of Cu from the target and evaluate the amount of hot electron produced
3) a CCD working in single-shot mode to record X-ray spectra and K-alpha emission to cross-check the results of K-alpha imaging

We present here the results from these diagnostics obtained in our experiment.

Employing nonlinear imaging microscopy for characterization of microlenses produced in different biocompatible materials

Aleksandar Krmpot[1, 2], George Tserevelakis[1], George Filippidis[1], Branka Murić[2], and Dejan Pantelić[2]

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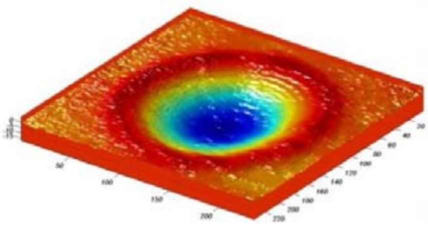
[2]*Institute of physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, SERBIA*

Microlenses and microlens arrays are extensively used in various applications: medical devices, wavefront sensors, confocal microscopy, imaging sensors and quantum computing systems [1-3]. Different materials are used in the production of microlenses, such as photosensitive glass, composites, and polymers, to mention just a few.

Knowing the properties of microlenses such as exact profile, diameter, index of refraction etc, is crucial in any application. Different methods are used for microlenses characterization such as thermal analysis [4] and stylus profilometry [5]. In this paper we present results for 3D imaging of microlenses and their characteristics obtained by different modalities of nonlinear microscopy. The microlenses used in this work are made in layers of three different materials: TESG (Tot'hema Eosin Sensitized Gelatin), BTS (Bethanine Sensitized Gelatine) and polymers used in dentistry.

Due to stepwise change of refractive index values at the microlens surface third harmonic generation (THG) of incident light is very efficient thus we preformed 3D imaging by THG microscopy using ultra short (femtosecond) laser pulses at 1028nm (fig 1a). Nonlinear microscopy modalities, THG and TPEF (two photon excitation fluorescence), used in this work are described in details in [6]. After imaged the microlenses by THG microscopy we used same data for obtaining other properties such as: profile, diameter, volume etc. Comparing profiles of single microlens, obtained in two mutually orthogonal planes, we are able to determine astigmatism.

BTS exhibit strong fluorescence, thus TPEF microscopy was used as diagnostic tool for imaging of changes of the material in the layer (fig 1b). Based on spatial distribution of THG signal one can estimate the spatial distribution of refractive index within the material under the microlens shape while TPEF measurements provide photochemical information. Namely, during process of building up the microlens which is basically done by irradiating the TESG layer by 532nm CW Nd-YAG laser beam, the thermal effects are pronounced and it leads to refraction index redistribution.


a)

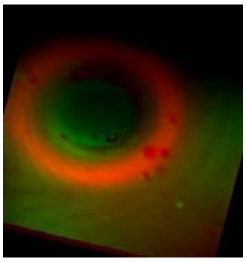

b)

Figure 1. a) *3D image of a microlens in TESG layer obtained by THG microscopy. By employing a special algorithm the depth of lens-air interface was determined. Depth distribution is presented in pseudo colors.* ***b)*** *3D image of microlens produced in BTS layer obtained by THG (green) and TPEF (orange) microscopy. More intense green/orange color corresponds to more intense THG/TPEF signal*

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GeV electron acceleration experiment at Astra-Gemini

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A Laser-Wakefiled acceleration (LWFA) experiment, aiming the production of high-quality electron relativistic beams, was performed at Astra-Gemini Laser Facility under Laserlab access program. The interaction was performed using sub-50 fs laser pulses with energies in the range 4 - 10 J and structured gas cells with lengths of 2 - 4 cm filled with hydrogen as target.
Preliminary analysis of the data indicate that reliable and reproducible electron beams with energies close to 1 GeV can be produced in a single stage. The use of plasma channels to enhance the acceleration process was also tested resulting in a significant energy gain signature although the data set is limited. These results, open the possibility of using this facility to test a double stage LWFA in the near future.

LASERLAB-EUROPE User Training activities

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User training activities in LASERLAB-EUROPE are focused at increasing the experience of Access Users providing special experimental and theoretical skills that are instrumental in specific areas of laser science, and expand the pool of prospective Users in new areas of science. The User Training activities are based namely on periodical User Training Schools, supplemented by User Training for Advanced Optical Techniques in Bio-imaging and Bio-processing which is a specialized user training programme provided by the Access Training Facility – Chemistry LASER Lab Coimbra, Portugal (CLLC). The focus of these actions is to increase the quality and/or to expand the pool of prospective Users and is targeted mostly to:

i) new research groups, e.g. from new members states within the EC or groups from other scientific disciplines (biology/medicine) whose participation in the Access program is gradually increasing;

ii) younger scientists, at the doctoral or post-doctoral level, while respecting the diversity and specific needs for different levels of collaboration with LASERLAB-EUROPE infrastructures.

In both cases, training actions aim at increasing the experience of the potential Users, and at providing special experimental skills that are instrumental in specific areas of laser science.

Taking into account the geographical varieties as well as wide spectrum of research areas covered by project consortium, three tailored *User Training Schools* have been organized so far since the start of the second phase of LASERLAB-EUROPE project: the Regional Baltic / Northern Europe Training School for potential users - Laser Applications in Spectroscopy, Industry and Medicine, held in Riga, Latvia, April 22 – 25, 2010; Iberian User Training workshop promoting the users community of High Power lasers (TW-PW), held in Salamanca, Spain, 8 - 9 November 2010; and finally Central-European User Community Training School - Advanced Optical Techniques in Bio-Imaging, held in Bratislava, Slovakia, July 4 – 7, 2011. In addition to these training workshops, additional schools were organized in collaboration with external partners, such as PYLA, France: Laser created secondary sources of electromagnetic radiation and energic particles, held in Bordeaux, France, Sept. 21-25, 2009 and Societa Italiana di Fisica: Enrico Fermi International School of Physics, Course CLXXXI - Microscopy Applied to Biophotonics, Varenna, Italy, July 12-22, 2011.

Specific *short-term training visits* were designed to increase the experience of potential European Users and to provide European scientists with special experimental skills and competencies in the scientific area related to the JRA OPTBIO. During the first year of the LASERLAB-EUROPE 2, proposals from six distinct European countries (Poland, England, Wales, Ireland, Italy, and Spain) were received by CLLC. During the reported period, four visits have been performed, half of which were lead by women. Training visits typically lasts for 2-3 weeks and in total 43 full experimental laser days has been provided during the visits.

The LASERLAB-EUROPE provides not only exclusive technical infrastructure, but also fruitful base for mentoring and collaboration in various fields of photonics/ laser research. Institutions and personnel participating in the User Training Schools has been subjected to number of joint discussions and brainstorming activities at different occasions, with the common goal of gradual optimization of the form and content of the Training. These include close collaboration with the User representatives and regular visits at User meetings, periodically organized under the cover of LASERLAB Networking Activities.

Laser ablation produced nanoparticles for cancer diagnostics and therapy

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Due to theirabsorption cross-section being orders of magnitude higher than other materials, gold and silicon nanostructures (core-shells, nanorods) have become increasingly popular for light-induced hyperthermia (LIH) of cancer.This approach could be significantly enabled by using optical imaging to track the uptake and localization of the nanostructures within and outside tumors and,thereby,adjust the applied therapeutic light dose. However, exploiting contrastthat is based on the scattering properties of plasmonicnanoresonators does not match the resonant absorption characteristics and is normally masked by strong intrinsic tissue scattering. We report the achievement of optical contrast in biological tissuesdue toboth absorption and scattering properties, which establishes the paradigm for optical imaging using nanoresonators. This effect is demonstrated both in tissue *ex vivo* and by systemic administration of nanoparticles*in vivo* and is attributed toan enhanced nanoparticle-based light attenuationunder conditions of photon trapping in a highly disordered biological medium. The observed absorption contrast matches the optimum for LIH-based heat release and can be obtained with relatively small nanostructures (5-60 nm), which favors improvedtumor targeting and systemic clearance of contrast agents. Combined with the possibility of bright-field illumination, the absorption contrast can be employed for image guidance for light-induced cancer therapy, promising a radical improvement inthe efficacy of this technology.

Nonlinear excitation of tailored nanostructures (NEXT)

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LaserLab Europe (FP7), Project mbi 001663

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Abstract: The interaction of semiconductor nanostructures with ultrashort laser pulses was studied. VLS-grown ZnO nanorods were applied as frequency converters for interferometric autocorrelation and for the direct observation of bandgap lowering.

Nano-crystalline ZnO possesses extremely large second-order nonlinear optical coefficients [1,2]. Therefore, an enormous application potential is expected including ultrashort-pulse characterization. On the other hand, the basic excitation mechanisms are not fully understood so that further fundamental research is required. In frame of this project, we have undertaken initial joint experimental and theoretical investigations in this field. Nanorods were grown by a vapor-liquid-solid mechanism on sapphire substrates with Au as catalyst and by a vapour-solid mechanism with a ZnO buffer layer on quartz in a chemical bath [3]. For the first time, we have demonstrated the use of ZnO nanorods for sub-20-fs Ti:sapphire pulse characterization by performing interferometric autocorrelation measurements (Fig. 1). Multiphoton-excited band edge luminescence (BEL) in ZnO is another useful phenomena that might significantly support future medical and photonic technologies like photodynamic therapy and lasing [4,5]. The effect of bandgap lowering is found to strongly influence this multiphoton-excited BEL process. ZnO, both in bulk as well as in nano-crystalline form, was found to show this phenomenon at higher intensity [6,7]. In all these studies, narrowband Ti:sapphire fs-pulses at a center wavelength of 800 nm were used and the slope of multiphoton BEL as a function of intensity was found to be either around 2 or slightly higher. The bandgap of ZnO of about 3.33 eV exceeds more than 2 times the energy of the photon at 800 nm (1.55 eV) so that a slope of 3 has to be expected. The observed lower slope value, however, indicates the presence of two-photon absorption induced BEL due to bandgap lowering at higher intensity. A three-photon absorption at lower intensity could be an explanation but was not been found. Thus, a transition from three-photon excited to two-photon excited BEL in an intermediate intensity regime must happen. In none of the published papers has, to the best of our knowledge, this complete picture of intensity-dependent BEL been reported so far. This is an exciting result from joint systematic autocorrelation experiments at varying intensity.

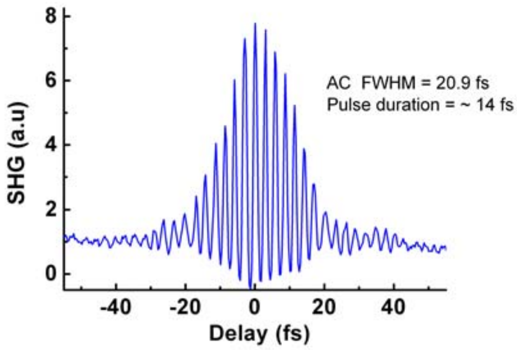

Fig 1. SHG interferometric autocorrelation trace of Ti:sapphire laser pulses measured with VLS-grown ZnO nanorods
(center wavelength 800 nm, pulse duration 14 fs).

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Electron beam and X-ray radiation generated by laser wakefield in dielectric capillary tubes

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Intense ultra-short laser pulse interacting with plasma expels electrons from the regions of high intensity and leaves in its wake a plasma wave. The ultra-high longitudinal electric field associated to this plasma wave is capable of accelerating electrons to hundreds of MeVs over only a few millimeters, which is called laser wakefield acceleration (LWFA for short). In the highly non-linear "bubble" regime of laser wakefield, plasma electrons can be completely blown out of the intense laser region, and self-trapped in the accelerating potential of the plasma wave. Meanwhile, the accelerated electrons are submitted to transverse electric fields which make them oscillate transversely during the process of acceleration, and consequently an intense X-ray radiation is produced.

In the mechanism of LWFA, the focused laser must be properly guided to counteract its natural diffraction. Using dielectric capillary tube to guide laser is promising [1], as it can collect the laser energy in the wings of the focal spot and assist laser self-focusing over a longer distance, compared to a gas jet or gas cell [2].

Recently an experiment was performed at the Lund Laser Centre (LLC) in Sweden. The Ti-sapphire laser facility delivers laser pulse with energy of 650 mJ on target within a FWHM duration of about 40 fs. When the laser is focused into the capillary tubes filled with hydrogen gas, tens of pC electron bunches are accelerated up to about 200 MeV. In particular, an intense X-ray beam is generated with a brightness of up to 1×10^{21} ph/s/mm^2/mrad^2/0.1%BW, which is 30 times higher than that obtained with a 2 mm gas jet operating in the same laser condition [3]. The details about those findings will be presented.

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Towards a Laser Based Compact Magnetic Fusion Device

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The main aim of our proposed project is to develop, in near future, a laser based compact magnetic fusion device (see fig. 1a) in open magnetic topology for high neutron flux production and study fusion process in high density and high temperature plasmas. Experimental studies[1, 2, 3] confirm that high intensity ultrashort laser beam interaction with deuterated clusters could produce plasma with density up to 10^{18} cm^{-3} and D ions with high kinetic energy from 10 kev to 50 keV, capable to initiate D-D (or D-T) ion fusion nuclear reactions. The application of an external high magnetic field in mirror-like topology (see fig. 1b) enables to decreases the plasma expansion velocity, increases the trapping time of the plasma and improves the neutron production. The proposed project is based on the improvements and the assembling of a number of advanced technologies, including the ultra-short laser-cluster interaction[4], the high magnetic field generation[5] and the numerical calculations using a 2-D MHD code[6, 7] describing the spatio-temporal evolution of high density and high temperature plasmas in compact magnetic fusion devices. The proposed investigations will be performed in collaboration with the teams from the CELIA and the UHI100 – Saclay laser facilities.

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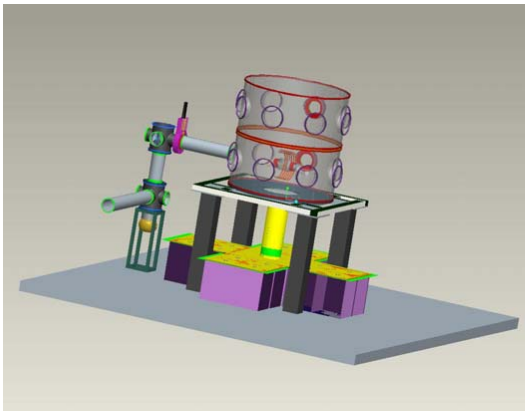

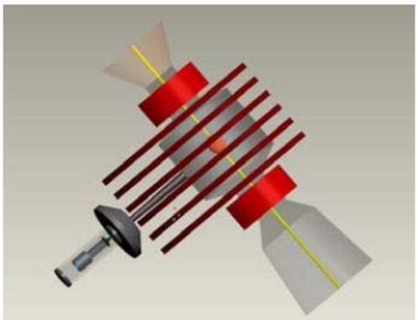

Fig. 1 Represents: [a] the proposed laser based compact magnetic fusion experimental set-up, including the capacitor bank producing the high magnetic field inside the experimental chamber, [b] the mirror-like magnetic field configuration with the double-single-turn coil (in red) and the high pressure gaze pulsed-nozzle producing the clusters. The yellow line represents the laser propagation in the experimental configuration and the *orange 'hot spot'* in the middle of the magnetic topology the lasercluster interaction.