



## Technical University of Crete

### Department of Sciences



## Matter Structure and Laser Physics Laboratory (MSLPL)

<http://www.physicslab.tuc.gr>

### About the Lab

The Technical University of Crete (TUC) was founded in Chania, Island of Crete, Greece as an independent technological institution of higher education. The philosophy behind its establishment was to host selected advanced technological and scientific studies and to create a centre of quality in the field of applied sciences. Within the framework of this philosophy the Senate of TUC approved and dynamically promoted in 1988 the establishment of the Matter Structure and Laser Physics Laboratory (MSLPL).

### Lab Research Activities

The research activities of the Matter Structure and Laser Physics Laboratory (MSLPL) are focused on the understanding of fundamental problems and questions related to the laser matter interaction applicable to the environment and the biomedical research areas. The Lab recognizing the need and the importance to society of modern technologies, adopted basic and engineering programmes with the objective of developing cost-effective analytical instrumentations and scientific tools to be used in various research areas.

In the spirit of the above, the MSLPL of the Technical University of Crete is currently performing high quality research in the subjects summarized bellow:

- Non-linear optics
- Laser induced photo-effects
- Solid-state and surface physics
- High intensity, pulsed x-ray production for micro-lithography, applicable to biomedical applications
- Laser based Electron and Ion pulsed source (ion guns and multi-ion source for ion implantation to semiconductors)
- Laser ablation and Laser time-of-flight mass spectrometric analysis
- Laser material deposition
- LIBS (Laser Induced Breakdown Spectroscopy), Ion and Electron spectroscopy

- In collaboration with the high intensity, ultrashort pulse laser facilities at “Laboratoire d’Optique Appliquée” (LOA) at Ecole Polytechnique in Paris, and at Rutherford Appleton Laboratory in UK we study the interaction of high intensity, short laser pulses with solids, gas and cluster targets. In particular we investigate the laser induced nuclear fusion reactions, the electron and proton acceleration during such high intensity laser matter interactions and the generation of the self magnetic fields
- Instrumentation development for studies involving ultrashort, high intensity laser interactions
- Harmonic generation from surfaces, atoms and clusters
- Non-linear optics and propagation studies of ultra-short, high intensity, IR and UV laser beam in atmosphere in collaboration with the IESL-FORTH (Institute of Electronic Structure and Lasers – Foundation of Research and Technology Hellas) and the LOA laboratories
- Opto-electronics and study of optical properties of materials
- Environmental and medical applications
- Detectors development

The MSLPL is a self-sufficient laboratory with its own research and engineering facilities such as mechanical, electrical and electronic workshops, CAD and computer animation facilities in order to improve technical design and construction of analytical instruments, electronic devices and software.

#### **Lab research facilities**

- Ti:Sapphire laser (Femtolasers GmbH, 800 nm, 20 fs, 75 MHz rep. rate)
- Nd:YAG laser (1064 nm (fundamental) up to 4<sup>th</sup> harmonic, 20 ns pulse duration, and 0-10Hz rep. rate), energy output : 850 mJ for the fundamental
- Nd:YAG diode pumped compact laser system (1064 nm (fundamental) and the 2<sup>nd</sup> harmonic @ 532 nm, few ns pulse duration, 0-500 Hz rep.rate), output energy : 5mJ for the fundamental.
- XeCl excimer laser (EMG 102 MSC Lamda Physik, 20 ns FWHM, 308 nm, 1-20 Hz rep. rate, 60 mJ/pulse average energy)
- Two Excimer Pumped Pulsed Dye Lasers (Lamda Physik Lambda-Physik, Model FL3002E, tunable wavelength variable from 185 to 975 nm)
- Two CW laser system @ 532nm for interferometry and holography experiments
- Digital oscilloscopes working at 1GHz up to 50 GHz sampling rate at single shot.
- A home-made time of flight mass spectrometer (TOF-MS) of high accuracy
- Commercial broadband spectrometers (UV – Vis – IR)
- Compact high resolution and sensitivity spectrometer for NIR up to UV.
- Imaging systems (CCD Cameras, Frame Grabbers)
- High vacuum systems (down to 10<sup>-7</sup> mbar)
- Experimental chambers for laser matter interaction and cluster production experiments

All the above assure the establishment of scientific research programs of high quality and allow the development of new technologies.

The Lab has the capability and capacity to design, develop and manufacture complex and advanced prototype instruments including micro-robotics linear-motion devices, laser based instruments, advanced interface electronics and software, laser time-of-flight mass spectrometers for surface analysis.

The current personnel of the MSLPL is consisted by 2 faculty members, 4 permanent laboratory staff, 2 PhD students and 6 postgraduate students. The scientific profile of the personnel is focused on laser development, laser matter interaction, optoelectronic devices development, measurements and calibration techniques, design and development of fast electronic devices, development of automatic systems controlled by micro-controllers, software development, design and development of complicate and high precision instruments such as time-of-flight mass spectrometer and high vacuum experimental set up for experiments and high quality measurements.

### **Relevant Research Grants and International Collaborations**

In collaboration with teams from laser facilities at “Laboratoire d’Optique Appliquee” (LOA) at Ecole Polytechnique in Paris, and at Rutherford Appleton Laboratory in UK using high intensity, short laser pulses we investigate the Laser Induced Nuclear Fusion Reactions, the electron and proton acceleration during ultra-short, high intensity laser interactions with different targets for high order harmonics generation from solid targets.

Investigations on Non-linear optics and propagation of ultra-short, high intensity, IR and UV laser beam in atmosphere in collaboration with the IESL-FORTH (Institute of Electronic Structure and Lasers –Foundation of Research and Technology Hellas) and the LOA (“Laboratoire d’Optique Appliquee” (LOA) at Ecole Polytechnique in Paris) Laboratories

### **Research Grants**

- 2010-2013 “WOOD-LASER”, on the laser processing of industrial wood, FINANCING ORGANIZATION: Ministry of Education, Project Thalys.
- 2008-2013: High Power Laser Energy Research Facility (HiPER), FINANCING ORGANISATION: European Union (FP7)
- 2008-2010: ELI : Extreme light Infrastructure, FINANCING ORGANISATION: European Union (FP7)
- 2006-2008: Application of ozone technology to agriculture products of Crete, FINANCING ORGANISATION: General Secretariat of Research and Technology (GRST), Greece.
- 2004 – 2006: Propagation of ultrashort and high intensity laser beam in the atmosphere with applications to the pollution measurements, FINANCING ORGANISATION: Ministry of Education, Project “Pythagoras”
- 2004-2005: CRINO European project
- 2001-2004: Suppression over High dynamic range of ASE at the Rising edge of ultra-intense femtosecond Pulses (S.H.A.R.P.) Contract no: HPRI – CT – 2001 – 50037, FINANCING ORGANISATION: European Union (FP5)

- 2001-2002: High magnetic field generation by laser-plasma interaction, FINANCING ORGANISATION : European Union (Marie Curie)
- 1995-1999: Development of a time-of-flight mass spectrometer for medical and biomedical applications, Composition analysis of solids, liquids and gases, FINANCING ORGANISATION: General Secretariat of Research and Technology (GRST), Greece
- 1996 – 1998: Multi-photon ionization of CFC and other molecules responsible for the O3 dissociation in the presence of various gases concentration and different temperatures, FINANCING ORGANISATION: General Secretariat of Research and Technology (GRST), Greece
- 1993-1994: Design and development of a micro-robotic device for 3-D movement and with a precision of  $10^{-6}$  m FINANCING ORGANIZATION: General Secretariat of Research and Technology (GRST), Greece
- 1991-1993: Ionization and dissociation studies of molecules in liquid and high density media, FINANCING ORGANISATION: European Union (ENVIRONMENT STEP)

#### List of selected publications of Lab staff (current and former) sorted by year

##### 2011

- Fragkedaki O., Kortsalioudakis N., Mixelioudakis M., Skoulakis A., Moustaizis S., "Microbial and Quality Control of Fruits and Vegetables by Ozone Application", 4th International Conference on Experiments/Process/System/Modeling/Simulation/ Optimization Athens, Greece, 6-9 July, 2011

##### 2008

- Ploumistakis I., I. Tsohantjis and S. D. Moustaizis, "New approaches on Laser Vacuum Breakdown for Pair Creation", 35th EPS Conference on plasma Phys., Hersonissos 9-13 June 2008 ECA Vol. 32D, P-1.123, 2008.
- Tsohantjis I., S. D. Moustaizis, I. Ploumistakis, "Pair creation from vacuum in the presence of ultra-intense laser beams", 35th EPS Conference on plasma Phys., Hersonissos 9-13 June 2008 ECA Vol. 32D, O-4.041, 2008.
- N. Kortsalioudakis, S.D. Moustaizis and S.Tzortzakis, "Ozone Concentration Control by Application of Filamented Ultrashort Ultraviolet Laser Pulses", 2nd International Symposium on Filamentation, 22-25 September 2008, Paris, France
- N. Kortsalioudakis, M. Michelioudakis, S. Moustaizis, "Study of the technology of Ozone (O3) in the maintenance of selected fresh agricultural products of Crete in order to create high quality modern units of packaging, storage and standardization", 2nd International Conference on Quality and Marketing of Agricultural Products, 25-27 September 2008, Hersonissos, Heraklion, Crete

##### 2007

- Tsohantjis I., S.D. Moustaizis, I. Ploumistakis, "On electron-positron pair production using a two level on resonant multiphoton approximation", Physics Letter B 650, 249-256, 2007.

##### 2006

- S.D. Moustaizis, E. Keskilidou and P. Lalouis, "Neutron flux Enhancement due to magnetic trapping of a Deuterium plasma produced by laser beam-cluster interaction", XXIX ECLIM, 29th European Conference on Laser Interaction with Matter, Madrid, Spain, June 11-16, 2006.
- N.Kortsalioudakis, E.Bakarezos, C.Kalpouzios, S.D.Moustaizis, "Development of Table-Top Ultrashort Hybrid Laser by Amplification of a Tuned Ti:Sa Laser Beam in an Excimer Double Cavity", CLEO/QELS 2006, Long Beach Convention Center, 21-26 May 2006, Long Beach, California, USA

- B. Dromey, M. Zepf, A. Gopal, K. Lancaster, M. S. Wei, K. Krushelnick, M. Tatarakis, N. Vakakis, S. D. Moustazis, R. Kodama, M. Tampo, C. Stoeckl, R. Clarke, H. Habara, D. Neely, S. Karsch and P. Norreys, "High harmonic generation in the relativistic limit", **NATURE** Physics, vol. 2, no 7, 456-490, 2006
- C. Kaberidis, I. Tsohantjis, S. D. Moustazis, "Multiphoton Approach on Pair Production under the Light of recent Experimental and Theoretical Investigation", *Frontiers of Fundamental Physics*, Springer, 279-283, 2006

## 2005

- N. Kortsalioudakis, M. Tatarakis, N. Vakakis, S. D. Moustazis, S. Tzortzakis, M. Franco, B. Prade, A. Mysyrowicz and N. A. Papadogiannis, "Phase matching control of harmonics generated during femtosecond ultraviolet laser propagation in Argon" *Appl. Phys B* 80, 211 – 214, 2005.
- P A Norreys, K L Lancaster, H Habara, J R Davies, J T Mendonça, R J Clarke, B Dromey, A Gopal, S Karsch, R Kodama, K Krushelnick, S D Moustazis, C Stoeckl, M Tatarakis, M Tampo, N Vakakis, M S Wei and M Zepf, "Observation of Ion Temperature exceeding background electron temperature in Petawatt laser-solid experiments", *Plasma Physics and Controlled Fusion*, 47, L49-L56, 2005.
- E. Keskilidou, S.D. Moustazis, L. Mikheev, P. Auvray, C. Rouiller, "Towards a Neutron Laser Driver", *Applied Radiation and Isotopes* 63, 671-680, 2005
- S.D. Moustazis, M. Tatarakis, A. Skoulakis and N. Kortsalioudakis, "An Innovative Scheme for Fast Charged Particles propagation", Fourth International Conference on Inertial Fusion Sciences and Applications, Biarritz France, September 2005.

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- N. Kortsalioudakis, E. Bakarezos, C. Kalpouzios, S.D. Moustazis, "A New Hybrid Laser System: Amplification of a Ti:Sa Laser Seed Beam in an Excimer Cavity Amplifier with Potential Applications to Atmospheric Pollution Monitoring", *Laser Olympics*, Athens, Greece Oct. 15-17, 2004
- S. Tzortzakis, N. Kortsalioudakis, M. Tatarakis, N. Vakakis, S.D. Moustazis, M. Franco, B. Prade, A. Mysyrowicz, N. Papadogiannis, A. Couairon, "Self-guided propagation of fs UV laser pulses and efficient harmonic generation in low pressure argon", *CLEO/QELS 2004*, The Moscone Center West, 16-22 May 2004, San Francisco, California, USA.
- M. Tatarakis, M. Bakarezos, N. Papadogiannis, N. Vakakis, N. Kortsalioudakis, S.D. Moustazis, P. Nilson, T. Witting, "Enhancement of the x-ray yield during the interaction of two collinear short pulse UV laser beams with a solid target", 8th International Conference on Applications of Nuclear Techniques, Crete, Greece Sept. 12-18, 2004
- S.D. Moustazis, M. Tatarakis, N. Vakakis and N. Kortsalioudakis, Jérôme Gaudin, and Philippe Martin, F. N. Beg, K. Krushelnick and A. E. Dangor, "Quartz induced Luminescence by Neutron impact using a Plasma Focus device", 8th International Conference on Applications of Nuclear Techniques, Crete, Greece Sept. 12-18, 2004

## 2002

- G. Grillon, P. Balcu, S.D. Moustazis et al. "Deuterium-Deuterium fusion dynamics in low-density molecular cluster jets irradiated by ultrafast laser pulses", *Phys. Rev. Lett.* 89 (6), 065005, 2002.
- G. Malka, M. M. Aleonard, J. F. Chemin, G. Claverie, M. R. Harston, J. N. Scheurer, S. Fritzler, V. Malka, P. Balcou, G. Grillon, S. D. Moustazis, L. Notebaert, E. Lefebvre, N. Cochet, "Relativistic electron generation in interaction of 30 TW laser pulse with a thin foil target", *Physical Review E* 66, 066402, 2002.
- G. Malka, S.D. Moustazis et al, "Nuclear Excitation with High Intensity and Ultra Short Laser Pulses", 29th EPS Conference on Plasma Phys. and Contr. Fusion, ECA Vol 26B, O-2.25, 2002.

## 2001

- S. Tzortzakis, B. Lamouroux, A. Chiron, S. D. Moustazis, D. Anglos, M. Franco, B. Prade, and A. Mysyrowicz "Femtosecond and picosecond ultraviolet laser filaments in air: experiments and simulations", *Opt. Commun.* 197, 131, 2001.

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- S. Tzortzakis, B. Lamouroux, A. Chiron, M. Franco, B. Prade, A. Mysyrowicz, and S. D. Moustazis, "Nonlinear propagation of sub-picosecond UV laser pulses in air" Opt. Lett. 25, 1270, 2000.

**1999**

- N.Papadogiannis, P.Loukakos and S. D. Moustazis, "Observation of the inversion of second and third harmonic generation efficiencies on a gold surface in the femtosecond regime", Optics Communications, 166, p133-139, 1 August 1999
- P.A. Norreys, M. Bakarezos, L. Barringer, M. Borgheshi, F.N. Beg, M. Castro-Colins, D. Chambers, A.E. Dangor, C.N. Danson, A. Djaoui, A. P. Fews, R. Gaillard, P. Gibbon, L. Gizzi, A.J. Mackinnon, C. Meyer, J. Meyer-ter-Vehn, S. D. Moustazis, S.G. Preston, A. Pukhov, S.J. Rose, M. Tatarakis, J.S. Wark, O. Willi, M. Zepf and J. Zhang "Studies of the fast ignition route to inertial confinement fusion at the Rutherford Appleton Laboratory", Fusion Eng.and Design 44, 239-243 (1999).

**1998**

- D.M.Chambers, P.A.Norreys, A.E.Dangor, R.S.Marjoribanks, S. D. Moustazis, D.Neely, S.G.Preston, J.S.Wark, I.Watts, M.Zepf "Feasibility study of high harmonic generation from short wavelength lasers interaction with solid targets", Optics Communications, 148, 289-294, 1998.
- F N Beg, S. D. Moustazis, M Tatarakis, P. Lee, A. Dyson and A E Dangor, "X-ray emission from plasmas formed using an excimer laser with different pulse lengths", Journal of Physics D, Vol 31, p2777, 21 Oct. 1998.

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- N.Papadogiannis and S. D. Moustazis, "Non-linear enhancement of the efficiency of the second harmonic radiation produced by ultrashort laser pulses on a gold surface", Optics Communications 137, pp. 174-180, 1997
- N.A.Papadogiannis, S. D. Moustazis, P.A.Loukakos, C.Kalpouzos, "Temporal Characterization of Ultra-short laser pulses based on multiple harmonic generation on a gold surface", Appl. Physics B-Laser and Optics, Vol. 65, 339-345, 1997
- N.A.Papadogiannis, S. D. Moustazis, J.P.Girardeau-Montaut, "Study of electron relaxation phenomena on copper surface via non-linear ultrashort single-photon photoelectric emission", J. Phys. D: Appl. Phys., Vol., 30, 2389-2396, 1997
- M.Tatarakis, F.N.Beg, P.Lee, A.E.Dangor and S. D. Moustazis, "X-ray emission from plasmas generated by 450 femtosecond excimer laser pulses", Physica Scripta, Vol. 55, 651-653, 1997

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- P.A.Norreys, M.Zepf, S. D. Moustazis, A.P.Fews, J.Zhang, P.Lee, M.Bakarezos, C.N. Danson, A.Dyson, P.Gobbon, P.Loukakos, D.Neely, F.N.Walsh, J.S.Wark and A.E.Dangor "Efficient XUV harmonics generated from picosecond laser pulse interaction with solid target", Phys. Rev. Lett. Vol. 76(11), pp. 1832-1835, 1996
- J. Zhang, M.Zepf, P.A.Norreys, A.E.Dangor, M.Bakarezos, C.N.Danson, A.Dyson, A.P.fews, P.Gibbon, I.H.Key, P.Lee, P.Loukakos, S. D. Moustazis, D.Neely, F.N.Walsh, J.S.Wark, "Coherence and bandwidth measurements of harmonics generated from solid surfaces irradiated by intense picosecond laser pulses" Phys.Rev. A, vol.54 no1, 1-7, July 1996.
- M. Zepf, M.Castro, D.Chambers, A.E.Dangor, C.N.Danson, A.Dyson, A.P.Fews, P.Gibbon, M.H.Key, P.Lee, S. D. Moustazis, D.Neely, P.A.Norreys, S.G.Preston, J.S.Wark and J.Zhang, "Measurement of a hole boring velocity from Doppler shifted harmonic emission from solid targets" Phys. Plasmas 3, 3242-3244 (1996).
- M. Zepf, M. Castro-Cohn, D. Chambers, S.G. Preston, J.S. Wark, J. Zhang, C.N. Danson, D. Neely, P.A. Norreys, A.E. Dangor, A. Dyson, P. Lee, A.P. Fews, P. Gibbon and S. D. Moustazis, "Measurements of the hole boring velocity from Doppler shifted harmonic emission from solid targets", Physics of Plasmas, 3242-4244 (1996).