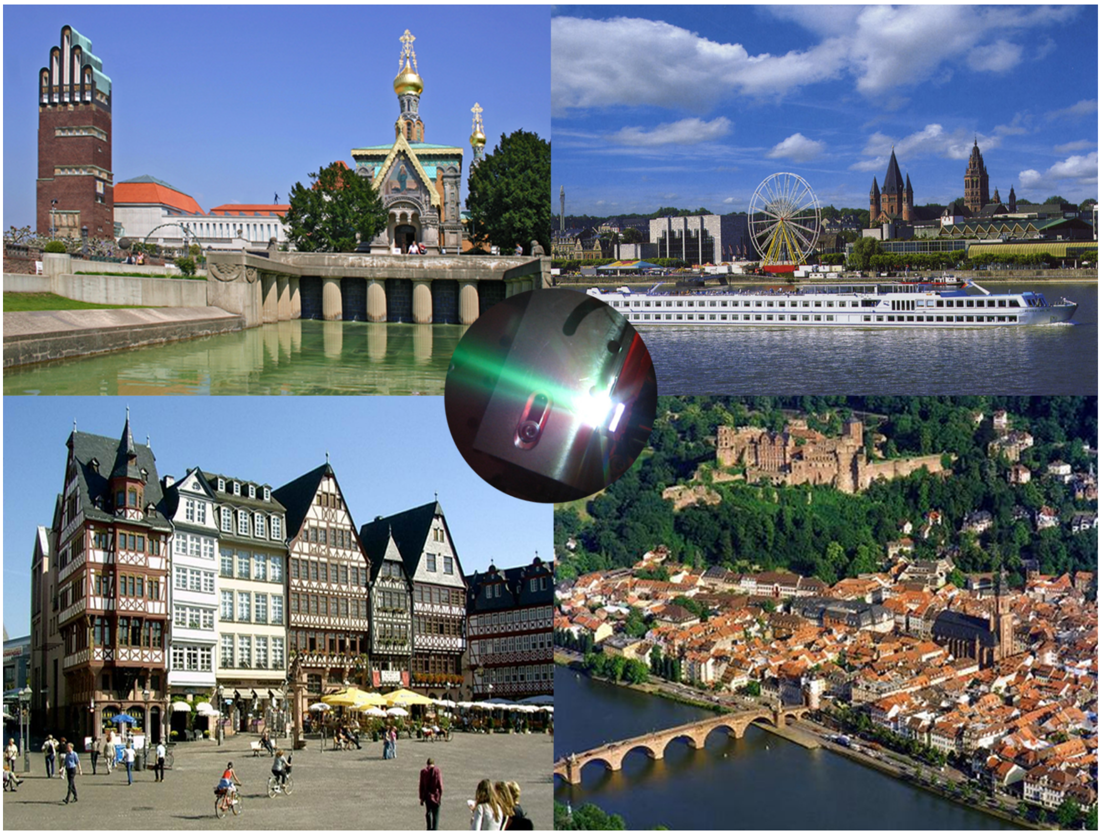
XXX ECLIM

30th European Conference on Laser Interaction with Matter
August 31 – September 5, 2008

Darmstadt Congress Center Darmstadtium
Germany



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LASER AND PARTICLE BEAMS

XXX ECLIM

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MO-01 — Monday 1st plenary session

MO-0101

State of the Art of the LMJ Laser System for Inertial Confinement Fusion

D. Besnard (CEA-DAM)

The Megajoule Laser (LMJ) program is a part of the French Simulation program. This laser will be able to deliver about 1.8MJ of UV light, to fulfill the program's requirements. The Megajoule Laser facility is devoted to high energy density plasma physics. It is designed for fusion achievement, but offers numerous other possibilities, e.g.: astrophysics, planetary physics, and dense matter physics. Achieving fusion with LMJ requires a coordinated program associating the facility itself, as well as optimized cryogenic fusion targets, plasma diagnostics, and simulation tools. An update about this overall program is presented. New results are overviewed, from the facility and operations, to cryogenic targets and plasma diagnostics. We identified high yield fusion capsules that require at most 1.4MJ of laser energy, offering new opportunities for operating LMJ. The corresponding experimental path to fusion is described and commented. LMJ and LIL (its 1-quad prototype) are unique facilities open to the scientific community. National and European developments are discussed. The building phase of the LMJ facility began in March 2003 and the civil works are completed; the target chamber has been introduced in the building in November 2006. The mechanical frameworks of the IR laser amplifying section are now being installed. This work is supported by a Government Agency.

1. P. A. Holstein et al, European Physical Journal D, 44, 239 /2007/
2. P. Baclet et al, Fusion Science and Technology, 49, 565 /2006/
3. J. M. Di-Nicola et al, Journal de Physique, IV, vol 133, 595 /2006/

MO-0102

HiPER - The European Path to Laser Fusion and Related Plasma Science

M. Dunne (RAL and HiPER)

Anticipating success on the National Ignition Facility, scientists from across Europe have prepared the case for a next generation laser fusion facility over the past 2 years. Called HiPER, this facility is being designed to achieve robust high gain (of order 100) via one of a number of advanced ignition schemes. Pursuit of the highest possible repetition rate is sought for HiPER, requiring coordinated work over the coming few years to establish the best technological solution to the laser driver and associated infrastructure, and to optimise the facility design for a broad-based approach to advanced ignition and a vibrant fundamental science programme. The facility proposal was accepted onto the European roadmap in October 2006, and has recently been funded for a 3-year 'preparatory-to-construction' phase starting April 2008. This talk will provide an update on the status of the facility, with details on the required developments over the coming years to ensure success.

MO-02 — Monday 2nd plenary session

MO-0201

Exotic Physics at Ultrahigh Laser Intensities

G. Mourou (LOA-ENSTA and ELI)

The Extreme Light Infrastructure (ELI) will be able to generate intensities in the range of 10^{25}-10^{26}W/cm^2. Aided by relativistic compression we may go as far as the Schwinger intensity. Part of the ELI charter is to explore physics in this unchartered territory, particularly in the field of nuclear physics, astrophysics, general relativity, nonlinear QED and cosmology. The laser at the core of the ELI project promises to deliver pulses of about 200 petawatts, i.e. power intensities 100,000 times higher than that of all the electricity-generating installations in the world. Moreover, the ultrashort time span of the laser's pulses, measurable in attoseconds or even zeptoseconds, is set to reduce by up to 10,000 times the distances needed by particle accelerators to produce particle or radiation beams. ELI therefore aims to fulfill a long-term ambition of physicists dating back to the birth of lasers in the 1960s: namely to break down vacuum into elementary particles and anti-particles via extreme laser intensities.

MO-0202

The National Ignition Facility and the Emerging New Era of High Energy Density Science

W. H. Goldstein, E. I. Moses (LLNL)

The National Ignition Facility (NIF) is nearing completion at Lawrence Livermore National Laboratory (LLNL). The NIF, the world's largest and most powerful laser system, is the U. S. Department of Energy (DOE) and National Nuclear Security Administration (NNSA) national center to study inertial confinement fusion (ICF) and the physics of extreme energy densities and pressures. NIF will produce 1.8MJ, 500TW of ultraviolet light. A number of the key technologies for NIF have been developed in collaboration with the Commissariat l'nergie Atomique (CEA), which is constructing a similar laser, Laser Mégajoule (LMJ), in Bordeaux, France. NIF concentrates the energy of up to 192 etremely powerful laser beams into a mm^3-sized target to conditions where they will ignite and burn, liberating more energy than required to initiate the fusion reactions. NIF will achieve temperatures about 10^8K, a radiation temperature of over $3.5\cdot10^6$K, densities of 10^3g/cm^3 and 100Gbar pressure. These conditions, never created in a laboratory, exist only in the interiors of the stars and during thermonuclear burn. The ability to study such conditions in laboratory will mark the beginning of a major new era in high energy density science. The NIF Project is scheduled for completion in March 2009. Currently, 176 of the 192 beams have been commissioned, producing over 3.6MJ of 1ω light and making NIF the world's first megajoule laser. Preparations are underway for 3ω target experiments in support of the National Ignition Campaign (NIC), a national effort aimed at commencing the first ignition experimental campaign in 2010. NIF will also perform experiments in fundamental high energy density science in areas such as laboratory astrophysics, material behavior at extreme conditions, and interaction of intense radiation fields with matter. Many of these experiments will be performed in collaboration with academic researchers. NIF will be operated as a user facility starting in late 2009. This talk will summarize progress on NIF construction and laser commissioning and discuss the status of the NIC. An overview of high energy density science experiments planned for NIF will also be presented.

MO-0203

Enhanced Ion Acceleration, Electron Confinement, and Material Heating in Intense Short-pulse Laser Interactions with Micro-structured Conical Targets

T. E. Cowan (FZ Dresden-Rossendorf)

Re-entrant conical laser target geometries have been studied for several years in the context of cone-guided fast ignition inertial fusion. The use of sharp-tipped cone targets has been proposed as a means to increase high-intensity short-pulse laser-target coupling [1]. Recently, significant improvements in both laser-acceleration of protons and material heating, have been achieved using novel micro-structured conical targets [2,3], in experiments at the LULI 100TW and LANL Trident lasers. This talk will review the fundamental laser-cone interaction physics, and its dependence on the target geometry and the pre-formed plasma conditions observed in experiments, and with the aid of collisional PIC simulations. We find that in the absence of pre-formed plasma, the laser pulse propagates to the cone wall, where strong (~10MG) quasi-static magnetic fields can be formed, which appear to confine electrons (of up to 100keV) and enhance the heating of the cone material. In the presence of a pre-formed plasma inside the cone, the laser pulse is largely absorbed before reaching the wall and magnetic confinement is not predicted. Rather, the generation of hot (MeV) electrons is increased and acceleration of protons by the TNSA mechanism can be enhanced with suitable target design, albeit with a larger shot-to-shot variability. The prospect for using such micro-structured targets for ion and x-ray sources for potential future medical applications will be discussed.

1. Y. Sentoku et al, Phys. Plasmas 11, 3083 /2004/
2. J. Rassuchine et al, J. Phys. Conf. Ser. 112, 022050 /2008/
3. K. Flippo et al, Phys. Plasmas 15, 056709 /2008/

MO-0204

Giant Planets as Laboratory for Warm Dense Matter

R. Redmer, N. Nettelmann, S. Lorenzen, B. Holst, M. French, A. Kietzmann (U Rostock)

Giant planets such as Jupiter and Saturn have attracted a renewed lively interest since the discovery of extrasolar planets. The study of their internal structure and evolution are key issues in this context. Furthermore, the interior of giant planets is a perfect laboratory to study warm dense matter. For instance, pressure and temperature inside Jupiter rise from almost normal conditions in the outer atmosphere up to about 20,000K and 40Mbar in the central core region. We have performed ab initio quantum molecular dynamics simulations to calculate highly accurate equation of state data for the most abundant planetary materials hydrogen, helium, and water in the warm dense matter region. These results can be probed by Thomson scattering experiments using brillant VUV or X-ray sources. The influence of our new data on the internal structure of giant planets is investigated and compared with standard results within a three-layer model. We study also interesting high-pressure effects such as the nonmetal-to-metal transition in hydrogen and helium, the demixing of hydrogen and helium as well as the exotic phase diagram of high-pressure water with a possible superionic phase. Our new ab initio results for the thermophysical properties of warm dense matter will improve our present understanding of the internal structure of giant planets.

MO-03 — Monday 1st parallel session

Fast Ignition Research at ILE, Osaka University

MO-0301

M. Murakami, H. Azechi, S. Fujioka, T. Jitsuno, N. Miyanaga, H. Nagatomo, M. Nakai, H. Nishimura, T. Norimatsu, K. Shigemori, H. Shiraga, K. Mima (ILE Osaka) A. Iwamoto, H. Sakagami (NIFS) R. Kodama, K. Kondo, K. A. Tanaka (Osaka U) Y. Nakao (Kyushu U)

Fast ignition has a potential to achieve ignition and burn with about one tenth of laser energy required for these programs. With the fast ignition, the fuel compression and heating are separated, with ignition initiated by a very short and high intense laser pulse incident on the already compressed fuel. The fast heating of compressed core [1], together with the scalability to high-density compression, has provided the scientific basis for the start of the Fast Ignition Realization Experiment (FIREX) project. The goal of the first phase (FIREX-I) is to demonstrate ignition temperatures of 5-10keV, followed by the second phase to demonstrate ignition and burn. Since the approval of FIREX-I, plasma physics study at ILE has been devoted to increase the coupling efficiency and to improve compression performance. In parallel to the orthodox fast ignition using PW laser, we now pursue another ignition scheme called Impact Fast Ignition [2], in which a fraction of fuel is accelerated to super-high velocities beyond 1000km/s to collide the compressed main fuel. In recent experiments, we have observed an increase in neutron yields by a factor of two order of magnitude due to the collision effect. This demonstrates the first proof of principle of the impact fast ignition.

1. R. Kodama et al., Nature 412, 798 /2001/
2. M. Murakami et al., Nucl. Inst. and Meth. Phys. Rev. A544, 67 /2005/

Generation and Transport of High Intensity Laser-generated Hot Electrons in Cone Targets

MO-0302

F. Beg, T. Ma, T. Bartal, M. S. Wei (UC San Diego) K. U. Akli, R. B. Stephens (GA) C. D. Chen (MIT) H. Chen, D. S. Hey, M. H. Key, S. Le Pape, A. J. Mackinnon, A. G. MacPhee, P. K. Patel, Y. Ping, R. P.J. Town, S. C. Wilks (LLNL) R. R. Freeman, A. Link, D. T. Offermann, V. M. Ovchinnikov, D. W. Schumacher, L. D. Van Woerkom (Ohio State U) W. Theobald (LLE Rochester) Y. Y. Tsui (U Alberta)

Fast ignition (FI) of inertial confinement fusion (ICF) proposes to ignite a pre-compressed DT target by the use of a separate high intensity short pulse laser. In advanced FI concept, a hollow gold cone embedded in the target facilitates transport of the laser energy to the vicinity of the compressed core through the low-density plasma of an imploded capsule. The short pulse laser generates the hot electrons at the cone tip, which subsequently heat the compressed plasma. Two parameters, i) conversion efficiency (from laser to hot electrons) and ii) hot electron temperature are significantly important for the success of fast ignition. In this talk, results from a series of experiments to study both parameters in cone and planar targets are presented. In addition, effect of the scale-length of the pre-plasma on fast electron production and energy coupling has been studied by systematically varying the prepulse energy (10mJ to 1J) produced by a separate long pulse laser. Experiments were performed on the Titan laser at the Lawrence Livermore National Laboratory. A 150J, 1ps laser (I $\sim 2\cdot 10^{20}$ W/cm^2) was focused by an f/3 off-axis parabolic mirror onto targets. The main diagnostics fielded were a copper Kalpha Bragg crystal imager, a single hit CCD camera spectrometer, a Highly Oriented Pyrolytic Graphite (HOPG) spectrometer and bremsstrahlung spectrometer. A comparison of experimental data with the simulations using PIC/hybrid code will be discussed.

MO-0303

High-Power Laser Beam Absorption by Anharmonic Resonance

P. Mulser (TU Darmstadt) D. Bauer (MPI Nucl. Phys.) H. Ruhl (R-U Bochum)

Two decades after the invention of chirped pulse amplification the physical mechanism of collisionless absorption of intense laser radiation in overdense matter is still not sufficiently well understood. We show that anharmonic resonance in the self-generated plasma potential may represent the leading physical absorption mechanism in the absence of efficient collisional interaction. Resonance provides for the finite phase shift of the free electron current, which is compulsory for laser beam energy transfer to any medium, and is capable of explaining the instantaneous generation of the fast electrons exceeding many times the quiver energy in the laser field, the high level of absorption up to 70-80%, as well as its behaviour with respect to linear and circular polarization. Recent experiments with ultrashort intense laser pulses are analyzed in the light of the new model and existing former theoretical approaches are critically reviewed.

MO-0304

High Harmonics in the Relativistic Regime

T. Baeva (U Düsseldorf)

The emerging high power laser technology opens a way to fascinating physical phenomena at ultra-relativistic intensities. One such phenomenon which intrigues with its universality is the generation of multiples of the laser frequency during laser-matter interaction. More than 3000 harmonics were observed in a recent experiment. This talk presents the history of the high harmonics from overdense plasma, starting from their first observation in the early 1980s. The presentation covers the basic ideas which were developed over the years in order to describe the harmonic generation. The main focus of the talk is the theory of relativistic spikes which explains the high harmonic phenomenon. The physical picture of ultra-intense laser-plasma interaction as well as the experimental confirmation of the theory is presented.

MO-04 — Monday 2nd parallel session

Development of Laser Driven Particle Sources and their Application to Science, Industry and Medicine

H. Daido (PMRC/APRC JAEA)

We have systematically performed high intensity physics experiments using an Optical Parametric Chirped pulse amplification system coupled with a Titanium Sapphire laser amplifiers with laser power of up to ~100TW. An ultra-high intensity laser driven particle acceleration has firstly proposed by Tajima and Dawson in 1979. Since then, a lot of researches have been performed by many groups. For example, since 2001, a five year project 'Research and Development of Elements of Advanced Compact Accelerators (RDEACA)' started by JAEA, Kyoto University etc. organized by National Institute of Radiological Sciences. The team has completed MeV ion beam generation driven by a laser as well as improved the ion beam energy spread by the phase rotation method. JAEA and HIBMC have established laser-driven beam treatment plans for cancer in general, and for uveal melanoma and age-related macular degeneration as niche treatment in particular. Based on these collaborative achievements, we have started the photo-medical valley project in which we are planning to develop a laser driven medical accelerator together with the development of monitoring technique such as an auto activation PET technique with strong collaboration with medical and industrial people. We will also develop industrial applications as a spin off of this project.

Effect of Plasma Density Scale Length on the Properties of Bremsstrahlung X-ray Sources Created by Picosecond Laser Pulses

C. Courtois, A. Compant La Fontaine, O. Landoas, E. Lefebvre, G. Lidove, V. Méot, P. Morel, R. Nuter (CEA-DIF) A. Boscheron, J. Grenier (CEA-CESTA) M. M. Aléonard, M. Gerbaux, F. Gobet, F. Hannachi, G. Malka, J. N. Scheurer, M. Tarisien (U Bordeaux)

Results of an experimental study of multi-MeV Bremsstrahlung X-ray sources created by picosecond laser pulses with application to radiography are presented. The X-ray source is created by focusing the short pulse on a solid tantalum target coated with plastic (CHO). Interaction conditions are modified by irradiating the target front side with a secondary nanosecond heating laser beam smoothed with a phase plate. This leads to the creation of a relatively smooth extended plastic plasma which is believed to improve the absorption of the short pulse energy. The length of the expanding plasma is modified by adjusting the delay between the interaction and heating beams. Plasma size is inferred from shadowgraphy and laser interferometry measurements. The high energy part of the X-ray spectrum and emission lobe is inferred from photo-nuclear activation techniques using copper and carbon samples. X-ray dose is measured with filtered silicon diodes. Two-dimensional images of the source are reconstructed from penumbral images decoded with an autocorrelation method. These results indicate the creation of a relatively small source, below 200μm diameter, that is potentially interesting for MeV radiography application. These diagnostics give access to a whole set of coherent experimental results on the X-ray source properties which are compared to extensive numerical simulations. Results show that the longer the preformed plasma, the brighter and the more uniform the source with higher dose and harder X-ray spectrum.

MO-0403

Theory and Ab Initio Simulations for X-Ray Scattering in Warm Dense Matter

J. Vorberger, K. Wünsch, D. O. Gericke (U Warwick)

X-ray scattering is an emerging new diagnostic method for dense plasmas and warm dense matter. It is particularly interesting since it is capable of delivering information about temperature, charge state, density and collective modes in a system opaque in the visible. However, those measurements are not model-free and complementary theoretical predictions are needed. We use first principle quantum simulations (DFT-MD) and classical integral equations (HNC) to obtain information about the ionic structure and the electron cloud around the ions. We apply our method to warm dense aluminium, plastics, lithium and beryllium and compare to recent experiments. Our analysis shows that HNC solutions for electron-ion systems have very limited predictive power since the results strongly depend on the form of the applied quantum pseudo-potential. However, simple one component calculations using the well-known linear screening model for the strongly coupled ions predict the ionic structure rather well when compared to ab initio simulations. The combination of the techniques also allows for deeper insights into the properties of warm dense matter: we found a strongly repulsive short range part of the ion-ion potential and bound state wave functions broadened by correlations. Finally, we construct the weight of the ion peak in the scattering spectrum from the information obtained and find very good agreement with the measured data for well-tested warm dense Beryllium.

MO-0404

Repetitive Outbursts of Fast Carbon and Fluorine Ions from Sub-nanosecond Laser-produced Plasma

J. Krása, A. Velyhan, K. Jungwirth, E. Krouský, L. Láska, K. Rohlena, M. Pfeifer (Czech IP-AS) J. Ullschmied (Czech IPP-AS)

Repeated plasma outbursts were recognized analysing time-resolved currents of fast carbon and fluorine ions produced with sub-nanosecond pulses of the system PALS focused onto teflon and polyethylene (PE) targets. This effect deals with a repetitive occurrence of doublets of C^{6+} F^{9+} and C^{5+} F^{8+} ion peaks as well as triplets of C^{6+} C^{5+} C^{4+} ion peaks in the time-of-flight (TOF) spectra, whose TOF can be related to the same accelerating potential. The repeated occurrence of groups of doublets and triplets of ion peaks in TOF spectra with the increasing TOF can be characterized by a set of discrete potentials U_i, where the subscript i labels the ion groups from the fastest one (i=1) up to the slowest and in the TOF spectrum distinguishable one (i=N). It is shown that both the maximum velocity and the number N of the fast ion groups depend on the focus position with the respect to the target surface; the most advantageous focus position is about 200-300μm below the target surface. The fast ion groups expand with the peak velocity up to $\sim 9\cdot 10^8$cm/s. The corresponding value of the accelerating potential was determined to be ∼650kV. The focus-position dependence of the maximum ion velocities and, thus, of ion kinetic energies shows that there exists a non-linear interaction of the focused laser pulse with the preformed plasma. Moreover, the discrete values of the accelerating potential U_i can indicate a plasma pulsing followed by repetitive outbursts of the fast C and F ions. This work was partly supported by the Grant Agency of the ASCR - grant IAA 100100715.

MO-05 — Monday 3rd parallel session

Current Status of Designing SBS PCM based IFE Driver

MO-0501

M. Kalal, O. Slezak, M. Martinkova (Czech TU) H. J. Kong, J. W. Yoon (KAIST)

New development in our proposal to employ SBS PCM based IFE laser driver scheme potentially capable of dealing with many important issues encountered in the IFE technology (in particular the required high repetition rate of the drivers and self-navigation of the drivers on the injected pellets) took place. A series of experiments was performed to test the idea of the higher harmonic conversion directly embedded into the SBS PCM driver. Subsequently a closer look was turned towards the actual energetic design of one typical channel:

1. to keep the energy of initial illumination of the injected pellet low enough to ensure that no harm, e.g. heating, will be done to the pellet itself,
2. to achieve sufficient amplification by the chain of amplifiers to bring the energy of the pulse to the level ∼1J before entering the SBS cell,
3. to reach the final energy of the pulse for the pellet irradiation ∼1kJ,
4. to maximize the energy extraction efficiency from individual amplifiers,
5. to design the necessary pulse shape required for IFE.

It turns out that the energies for the SBS PCM reflection of the order of 1J would require a very large amplification of the illumination signal (first pass). Unless some measures would be taken this would result in very high energies for pellet irradiation (per channel) after the second pass - thus limiting the total number of channels to be employed. As the main idea of the proposal is favoring rather higher number of less energetic drivers, overcoming this hurdle seems to be one of the most important current issues.

Four-beam Combination Laser Amplifier System using Stimulated Brillouin Scattering Phase Conjugate Mirrors

MO-0502

H. J. Kong, J. W. Yoon, J. S. Shin, D. H. Beak (KAIST) Y. S. Kim (Dankook U)

The beam combination laser system using stimulated Brillouin scattering phase conjugate mirrors is expected as one of the promising methods for high energy/high repetition rate. In this work, we construct a four-beam combination laser amplifier system with double pass amplification using proposed self-phase control technique.

Investigation of Stimulated Raman Scattering using Short-Pulse Diffraction Limited Laser Beam near the Instability Threshold

MO-0503

J. Kline, D. S. Montgomery, L. Yin, K. A. Flippo, R. P. Johnson, T. Shimada, B. J. Albright, H. A. Rose (LANL) C. Rousseaux, V. Tassin (CEA-DIF) S. D. Baton, F. Amiranoff (LULI) R. A. Hardin (West Virginia U)

Short pulse laser plasma interaction experiments using diffraction limited beams provide an excellent platform to investigate the fundamental physics of both Stimulated Raman Scattering and Stimulated Brillouin Scattering. Detailed understanding of these laser plasma instabilities impacts the current inertial confinement fusion ignition designs and could potentially impact fast ignition when higher energy lasers are used with longer pulse durations (>1kJ and >1ps). Using short laser pulses, experiments can be modeled over the entire interaction time of the laser using particle-in-cell codes to validate our understanding quantitatively. Experiments have been conducted at the Trident laser facility and the LULI (Laboratoire pour l'Utilisation des Lasers Intenses) to investigate stimulated Raman scattering near the threshold of the instability using 527nm and 1064nm laser light respectively with 1.5-3ps pulses. In the case of both experiments, the interaction beam was focused into a pre-ionized He gasjet plasma. Measurements of the reflectivity as a function of intensity and k_D were completed at the Trident laser facility. At LULI, a 300fs Thomson scattering probe is used to directly measure the density fluctuations of the driven electron plasma and ion acoustic waves. Work is currently underway comparing the results of the experiments with simulations using the VPIC [K. J. Bowers, et al., Phys. Plasmas, 15 055703 /2008/] particle-in-cell code. Details of the experimental results will be presented.

MO-0504

Collisional Absorption in Dense Plasma – Localised Strong Collisions and Collective Excitation

A. Grinenko, D. O. Gericke (U Warwick)

We investigate the collisional absorption of laser energy in dense plasmas which is, for intermediate laser intensities, the dominant absorption process. The presented approach bridges the well-developed theories in the low and high frequency limits and is also not restricted with respect to laser intensity. It is shown that friction/collisions in any order can be described by a general stopping force. Therefore, the well-developed approaches for the stopping power, that include the effects of strong collisions and collective excitations (plasmons), can be applied as an additional external force in the Vlasov-Poisson equations. The electrons are assumed to have an equilibrium distribution in their rest frame which is here calculated by incorporating both the driving field and the friction due to collisions. Accordingly, solution of Vlasov-Poisson equations in electron rest frame enables us to obtain both limiting cases of laser field asorption in the highly collisional (DC-conductvity) and in the weakly collisional (dielectric theory) systems at high laser frequencies. In contrast to previous approaches, the results of the presented theory are in excellent agreement with the molecular dynamics simulations even for very dense plasmas.

MO-06 — Monday 4th parallel session

Demonstration of Control of Capsule Implosion Symmetry in NIF Hohlraums

MO-0601

G. A. Kyrala, A. Seifter, J. Kline, N. M. Hoffman, D. C. Wilson, S. R. Goldman, N. D. Delamater (LANL)

Implosions using inertial confinement fusion must be highly symmetric to achieve ignition on the NIF. This requires precise control of the drive symmetry from the radiation incident on the ignition capsule. For indirect drive implosions, such as designed for the NIF laser, we may adjust the symmetry using many methods. We have used two such methods, using either beam pointing, or power imbalance [phasing] of three or two cones from the OMEGA laser to control the symmetry of an imploded capsule. For pointing and phasing we used a NIF 0.7 scale vacuum-hohlraum and D_2-filled 1400μm CH and Beryllium capsules to verify the technique. We captured images at different times for different pointings of the inner and middle laser cones of OMEGA, verifying the technique and demonstrating symmetry tuning. For phasing, we also used a 1/4 scale NIF vacuum-hohlraum was used to drive a 475μm diameter D_2-^{3}He-filled capsule. Imaging of the imploded core was used to measure the implosion symmetry and to verify its. We also showed that propagation of the inner beam cone is important, even in a vacuum hohlraum, and had the largest effect on the hohlraum energetics. Work supported by US DOE/NNSA, performed at LANL, operated by LANS LLC under Contract DE-AC52-06NA25396. LA-UR-08-4298

Decreased Ignition Threshold for Laser Fusion with Nonlinear Force Driven Plasma Blocks

MO-0602

H. Hora (U New South Wales)

Anomalous interaction of ps laser pulses of TW to PW power is due to suppression of relativistic self focusing if prepulses are cut off by a contrast ratio higher than 10^8 resulting in space charge neutral plasma blocks with DT ion current densities above 10^{11}A/cm^2 [1]. This is rather too high for ignition of solid state density DT if the energy flux density E* has to be higher than the threshold of $4{\cdot}10^8$J/cm^2 derived by to the theory of Chu (1972). A revision of this evaluation shows a reduction of this threshold by a factor 20 if the later discovered inhibition factor for thermal conduction because of double layer effects [2], and if the shorter stopping lengths of the alphas from the reaction due to the collective effects are included. These results may also lead to a relaxation of the conditions for central ignition of laser fusion. Results on a block ignition with the reduced threshold are reported within the limits that the irradiated ion energies have not to be higher for DT than 80keV in the directed blocks for the resonance of the fusion cross sections.

1. H. Hora, J. Badziak et al. Phys. Plasmas 14, 072701 /2007/
2. M. Ghorannviss et al. Laser and Particle Beams 26, 105 /2008/

Low Velocity Ion Stopping in Dense and Strongly Magnetized Plasmas

MO-0603

C. Deutsch, R. Popoff (LPGP)

Plasma stopping of projectile ions with a velocity below the target thermal electron velocity in the presence of an arbitrary large magnetic field, up to now, remained a theoretical endeavor of a daunting complexity. For instance, the crucial directions parallel and orthogonal to the applied magnetic intensity are thus plagued with many divergences and ill-resolved technical assumptions. Starting with a description of low velocity ion stopping (LVIS) in terms of inverse Kubo-Green integrands, we come up with well-defined analytic expressions for basic quantities of fundamental concern in fast ignition physics for inertial confinement fusion as well as for ultra-cold plasmas envisioned for ion beam cooling at CERN.

MO-0604

Directional Bremsstrahlung from a Ti Laser-produced X-ray Source at Relativistic Intensities in 3-10keV Range

F. Zamponi, A. Lübcke (MBI Berlin, FS-U Jena) T. Kämpfer, I. Uschmann, E. Förster (FS-U Jena) L. Labate, P. Koester, T. Levato, L. A. Gizzi, D. Giulietti, A. Giulietti (ILIL-IPCF)

A high-resolution 2D imaging system was used to monitor the front and the rear side emission of a laser-plasma X-ray source, created by focusing 80fs, 600mJ laser pulses at intensities up to approximately $5{\cdot}10^{19}$W/cm^2 onto Ti thin foils. To our knowledge, for the first time large differences in dimension and photon yield of bremsstrahlung (even for 5μm thin Ti target) between the front and rear emission were found. Postprocessing of the measured data allowed for the extraction of space resolved X-ray spectra: a massive presence of bremsstrahlung only on the front side could be detected. Directional bremsstrahlung is proposed as an explanation for the front-rear side emission differences as predicted by Sentoku et al. and Sheng et al. References:

- Y. Sentoku et al., Physics of Plasmas, 6, /1999/ 2855
- Z. M. Sheng at al., PRL, 25, /2000/ 5340.

MO-07 — Monday 5th parallel session

MO-0701

Compression and Thermonuclear Yield of Laser Targets under Conditions of HiPER Facility with due to Regards for Irradiation Asymmetry

V. Rozanov, S. Yu. Gus'kov, N. Demchenko, I. Doskoch, R. Stepanov, R. Yakhin (LPI RAS) M. Perlado (DENIM UP Madrid) N. Zmitrenko (IMM RAS)

Within the framework of the Fast Ignition HiPER program it is proposed to develop a power reactor operating in the rate regime. The 1D calculations of symmetrical compression predict an acceptable thermonuclear yield of G∼100. The number of the target irradiating beams in a reactor chamber will admittedly be less than that in the experimental arrangement (www.hiper-laser.org), i.e. under the essentially reduced symmetry of compression. In the known schemes of reactors (HYLIFE, KOYO-F), one might use 2-32 beams for the target compression, which are in or near the equatorial target plane. The 'downward' directions are less accessible because of the liquid lithium flows, while the 'upward' direction are for the ignition beam. In this report we consider the effect of the compression asymmetry on reduction of thermonuclear yield for 2-32 beams. The proposed procedure includes [1] making of 3D irradiation maps and light histograms depending on the number and parameters of laser beams; 1D calculations of compression of differently illuminated parts of targets; 2D calculations made on the basis of 3D maps and histograms for a target asymmetric compression; 2D calculations of ignition and burning of targets according to the Fast Ignition scheme [1]. The work was supported by the RFFI Grants #08-02-91202 JF, 08-01-00291.

1. V. Rozanov et al. Analysis of the foam-absorber capsules symmetry compression under irradiation condition of Iskra-5 laser facility, IFSA 2007, http://www.iop.org/EJ/abstract/1742-6596/112/2/022006

MO-0702

Analysis of the Energy Transfer in Low-density Structured Foam-like Targets in the Experiments on the LIL Facility

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Experiments on irradiation of targets made of a low-density structured material were performed on the LIL facility. The laser pulse parameters were as follows: energy 10kJ, duration 3ns, intensity $4{\cdot}10^{14}$W/cm^2, wavelength 351nm. This paper presents a theoretical analysis and results of numerical modeling of the energy transfer in the target obtained in one- (RAPID) and two-dimensional (LATRANT) numerical calculations. The calculation procedure had been developed earlier for the analysis of analogous experiments performed on the PALS facility [1]. However, in the present experiments the laser parameters are different: the pulse duration is 4 times longer and the energy delivered is more than 100 times greater. The numerical modeling successfully reproduces the major experimental results: the energy balance, the evolution of plasma temperature and density. The velocity of the thermal front was calculated with a post-processor that describes the X-ray radiation emission and propagation to the detector. The work was partially supported by the RFFI Grants #08-02-91202 JF and 08-01-00291. The experimental work was coordinated under the auspice of the Institute Lasers and Plasmas. The authors acknowledge the support of the operation team of the LIL facility who made these experiments possible.

1. V. Rozanov et al. Energy transfer in low-density porous targets doped by heavy elements, IFSA 2007, TuPo26, http://www.iop.org/EJ/abstract/1742-6596/112/2/022010/

MO-0703

Compression and Thermonuclear Yield of the Laser Targets for the Fast Ignition Installation HiPER under an Influence of Irradiation Asymmetry.

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The different variants of targets irradiation are considered (from 2 up to 16 beams). The evaluation of the influence of an arising asymmetry, which leads to a reduction of the thermonuclear yield, was done. The method is based on 3D maps of illumination, depending on number and features of laser beams, 1D simulations of a compression for the different values of laser intensity, 2D calculations of the targets compression, which take into account real irradiation asymmetry and 2D simulations of the ignition and burn, reproducing the Fast Ignition Scheme.

MO-0704

Observation of Quasi Mono-energetic Electron Bunches in New Ellipsoid Cavity Model

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For high intensity laser pulses shorter than the plasma wave-length, bubble acceleration has been identified by Pukhov and Meyer-ter-Vehn [1]. Although in previous works the generation of well collimated ultra short MeV electron bunches in this regime was described by sphere cavity model, but cavity shape is more like an ellipsoid [2]. In this work we present a new ellipsoid model and discuss appropriate conditions of forming it for first time. We have found that the electron trajectory is strongly related to background electron energy and cavity potential ratio. We apply a tuning state and appropriate plasma profile to obtain an initial condition of ellipsoid cavity forming. We have noticed the electron output energy is not affected by elongation of transverse cavity radius in ellipsoid regime. In experimental part of this work: 20TW, 35fs laser pulse was focused on to a pulsed He gas jet; the quasi mono-energetic electron beam was detected. The proper conditions of such electrons are explained.

1. A. Pukhov and J. Meyer-ter-Vehn, Applied Physics B Lasers and optics, 74, 4-5, 355-361, /2002/
2. A. Pukhov, S. Gordienko, S. Kostyukov, Phys. Controlled Fusion, 46, B179-B186 /2004/

MO-08 — Monday 6th parallel session

Diagnostics and Equations of State in Laser-plasma Interaction, in particular Ellipsometry

S. Eliezer, Z. Henis, L. Bakshi, N. Nissim, L. Perelmutter, D. Moreno, M. Sudai (Soreq NRC)

A review of existing diagnostics in laser-plasma interaction relevant to the equation of state (EOS) study will be presented [1]. The ellipsometry is suggested and described for the EOS research. The detection of phase transitions of the first kind, solid-solid [2] and solid-liquid, as well as phase transition of the second kind will be analyzed and demonstrated. Furthermore, the measurement of temperature is a very important thermodynamic parameter in the EOS studies. The temperature measurements are not possible without the knowledge of the emissivity, a parameter that can be measured by ellipsometry techniques.

1. S. Eliezer and Z. Henis, Equations of State in Applications of Laser Plasma Interactions, Eds. S. Eliezer and K. Mima, Taylor and Francis Publication, New York /2008/
2. N. Nissim, S. Eliezer, L. Bakshi, L. Perelmutter, D. Moreno, E. Kot, G. Kh. Rozenberg and M. P. Pasternak, High-pressure phase transition detection in diamond anvil cell using the method of ellipsometry, J. Appl. Physics 102 , 106104 -1 to 3 /2007/

Multiphase Equations of State for Metals Irradiated by Intense Ultrashort Laser Pulses

K. Khishchenko (JIHT RAS)

The equation of state (EOS) for materials is required for numerical simulations of processes of intense pulsed influences on condensed media [1]. Matter irradiated by ultrashort laser pulses behaves as a two-temperature system of electrons and heavy particles (atoms, ions and nuclei). In this work, an EOS model for metals is proposed with taking into account the melting and evaporation effects in the two-temperature case. EOS's for some metals (aluminum, nickel, copper, silver and gold) are developed. As distinct from the previously obtained multiphase EOS for metals [1, 2], new functional expressions for the thermodynamic potentials are formulated. Those provide for a more correct thermal contribution of heavy particles in the liquid phase under rarefaction [3]. A critical analysis of calculated results is made in comparison with available experimental data for the metals at high energy densities.

1. A. V. Bushman, V. E. Fortov, G. I. Kanel and A. L. Ni, Intense Dynamic Loading of Condensed Matter, Taylor and Francis, Washington /1993/
2. V. E. Fortov, K. V. Khishchenko, P. R. Levashov and I. V. Lomonosov, Nucl. Instr. Meth. Phys. Res. A 415, 604 /1998/
3. M. E. Povarnitsyn, T. E. Itina, M. Sentis, P. R. Levashov and K. V. Khishchenko, Phys. Rev. B 75, 235414 /2007/

MO-0803

Developments in the Calculation of Radiative Properties of ICF Plasmas at DENIM

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Up to now, several computer codes have been developed for the calculation of optical properties of different plasmas, and also its diagnosis. In this way, DENIM has been working for more than twenty years in the development of computer codes for the calculation of radiative properties of plasmas. At the beginning, the main goal was to have a basic capability to obtain opacities of materials in hot dense plasmas, useful for hydrodinamic simulations. Several versions of codes were developed and published. However, in the last ten years the group participated in several proposals of experiments at dense plasmas and in its analysis. For this reason, we considered that our computer codes should iinclude tools needed for the diagnosis of these plasmas. Many changes have been included in the original codes, and as a result a set of codes have been fully developed at DENIM. Our codes coupled with other available codes permit at this time simulate experiments with a great deal and also obtain opacity data for hydrocodes. In this work we present these new developments and its validation with experiments. As an important value, our codes combine accuracy and provide results very rapidly.

MO-0804

Kinetic Approach of Laser-excited Metals

B. Omar, B. Rethfeld (TU Kaiserslautern)

Non-equilibrium distribution functions of electron gas and phonon gas are calculated for metals excited with ultrashort intense laser pulses. The excitation during femtosecond irradiation and the subsequent thermalization of the free electrons, as well as the dynamics of phonons are described by kinetic equations. The microscopic collision processes, such as absorption by inverse bremsstrahlung, electron-electron collisions, and electron-phonon interactions are considered by complete Boltzmann collision integrals. We apply our kinetic approach for gold by taking s-band electrons into account, and compare it with the case of excitation of d-band electrons.

TU-01 — Tuesday 1st plenary session

TU-0101

Modern Physics of Warm Dense Matter

V. E. Fortov (IPCP RAS)

The physical properties of hot dense matter over a broad domain of the phase diagram are of immediate interest in astrophysics, planetary physics, power engineering, controlled thermonuclear fusion, impulse technologies, enginery, and several special applications. The problems addressed by experiments in the field are of fundamental nature and deal with equations of states of supercompressed matter, plasma phase transitions, critical points of metals, anomalous conductivity, noncongruent phase transformations, and atomic physics with strong interparticle interactions. Intense radiation from particle and laser beams and the use of intense shock waves in dynamic physics and high-pressure chemistry has made the exotic high-energy-density states of matter subject of laboratory experiments and enabled advancing by many orders of magnitude along the pressure scale to range into the megabars and even gigabars. The present report reviews the latest experimental research involving shock waves in nonideal plasmas under conditions of strong collective interparticle interaction. The results of investigations into the thermodynamic, transport, and optical properties of strongly compressed hot matter, as well as into its composition and conductivity, are discussed. Experimental techniques for high energy density cumulation, the drivers of intense shock waves, and methods for the fast diagnostics of high-energy plasma are considered. Also discussed are compression-stimulated physical effects: pressure-induced ionization, plasma phase transitions, the deformation of bound states, plasma blooming ('transparentization' of plasma), etc. Suggestions for future research are put forward.

TU-0102

Energy Loss and Charge States of Argon Ions Penetrating Hot and Dense Carbon Plasma

A. Blažević, T. Heßling (GSI) A. Frank, M. Günther, K. Harres, D. H.H. Hoffmann, R. Knobloch-Maas, F. Nürnberg, M. Roth, A. Pelka, G. Schaumann, A. Schökel, M. Schollmeier, D. Schumacher, J. Schütrumpf (TU Darmstadt) H. G. Bohlen, W. von Oertzen (HMI Berlin)

A detailed understanding of interaction phenomena of intense ion and laser radiation with matter is important for a large number of applications in different fields of science, from basic research of plasma properties to application in energy science. Energy loss processes of heavy ions in plasma and cold matter are important for the generation of high energy density states in general and especially in the hot dense plasma of an inertial fusion target. At GSI the plasma physics group is investigating the interaction processes of swift ions penetrating laser (Phelix/nhelix) generated plasma. We present an overview on recent developments at the experimental area Z6, including the first experiment with the Phelix laser combined with the Unilac ion beam. Further on results on beam plasma interaction processes studied with an Ar ion beam penetrating a laser generated carbon plasma, combined with measurements at the HMI, where the charge state exchange processes as well as the energy loss of Ar ions in carbon foils were investigated in the non-equilibrium region, will be discussed. The experiments resulted in cross sections for the charge exchange processes and in charge state dependent stopping powers S(q). The combination of a charge state evolution and the corresponding S(q) values allows to reproduce the measured energy losses, even in the charge state non-equilibrium region. These cross sections for cold matter were recalculated for plasma conditions to be able to predict the charge state evolution in the plasma and consequently to explain the difference in the energy loss compared to cold matter.

Prospects of High Energy Density Matter Research at the FAIR Facility at Darmstadt and LHC at CERN: the HEDgeHOB Collaboration

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Gesellschaft für Schwerionenforschung (GSI), Darmstadt has a long tradition of accelerating intense, bunched beams of energetic heavy ions including uranium. The existing heavy ion synchrotron, SIS18, can deliver $4{\cdot}10^9$ uranium ions in a single bunch that is a few hundred ns long. The beam can be focused to a spot that has a diameter of 0.5-1.0mm. Numerical simulations have shown that this beam will induce about 1kJ/g specific energy in solid lead which is sufficient to achieve near critical states of lead. Construction of a new accelerator facility named FAIR (Facility for Antiprotons and Ion Research) at Darmstadt will substantially increase the existing accelerator capabilities of the GSI. It is expected that the uranium beam at FAIR will have an intensity of $5{\cdot}10^{11}$ ions and a bunch length of the order of 50-100ns. Numerical simulations have shown that this beam will deposit a few hundred kJ/g specific energy in matter that will allow one to carry out novel and unique experiments in the field of high-energy-density (HED) matter. Extensive theoretical work has been carried out to design novel experiments to be carried out at FAIR by the HEDgeHOB Collaboration to study HED states in matter. This work has shown that one can use three different experimental schemes for this purpose. Another huge accelerator facility that has already been completed, is the Large Hadron Collider (LHC) at CERN that will accelerate 7TeV proton beams. Numerical simulations have shown that the LHC has great potential for HED matter research.

TU-02 — Tuesday 1st parallel session

Target Physics and Materials for Inertial Fusion and Fusion Technology at DENIM

M. Perlado, A. Abanades, O. Cabellos, D. Díaz, S. Eliezer, B. Gámez, L. Gámez, N. G.-Herranz, C. García, M. Gonzalez, Y. Herreras, A. Lafuente, J. Martínez-Val, E. Martínez, E. Minguez, E. Oliva, E. del Rio, F. Sordo, M. Velarde, P. Velarde, G. Velarde, M. Victoria (DENIM UP Madrid) M. Caturla (U Alicante) R. Florido, M. Gil, P. Martel, R. Rodríguez, J. Rubiano (UP Madrid, U Las Palmas) M. García, D. López, F. Ogando, M. Piera, J. Sanz, P. Sauvan (DENIM UP Madrid, ETSII UNED) J. Marian (LLNL)

Radiation hydrodynamics simulations in relation with radiative shocks experiments hold at high-energy laser installations relevant for astrophysical situations have shed into light the importance of radiative losses on the shocks topology and dynamics. Calculations using ARWEN for Jet Impact Fast Ignition will be also presented. We have developed a computation package composed by two codes called ABAKO and RAPCAL that calculate atomic data and plasma level populations (ABAKO) and radiative properties such as opacities, emisivities, intensities or radiative power losses (RAPCAL) for optically thin and thick plasmas, both under LTE and NLTE conditions. The primary damage behaviour of the low activation steel Eurofer was studied under irradiation in the high flux test module of IFMIF and in the first structural wall of the magnetic (ITER, DEMO) and inertial (HYLIFE-II, HAPL) fusion energy reactors. The evolution of the elemental composition during irradiation shows a linear dependence with the irradiation time. H and He generation is also presented. 3D neutronics calculations for complex geometry are performed for KOYO-FI and ITER and assessment of fluid dynamics in Blanket Modules for inertial and magnetic concepts, and tritium diffusion will also be presented. The work done on FeCr alloys model for radiation damage simulations and experimental basis will be presented in detail in an international collaboration. In addition to work performed in IFMIF-EVEDA safety and test cells, a large effort is being performed to define a Laboratory for Fusion Technology with CIEMAT.

Laser Wakefield Electron Acceleration in Guiding Structures

N. E. Andreev, S. V. Kuznetsov, M. E. Veysman (JIHT RAS) B. Cros, G. Maynard (LPGP) P. Mora (CPT Palaiseau)

The coupling efficiency of an incident laser pulse to a capillary tube with a cone shape entrance is investigated. The laser pulse guiding in an evacuated capillary and wakefield generation in a gas filled capillary tube with and without cone entrance are discussed for an experimentally measured radial intensity distributions. It is demonstrated that the use of a capillary with cone entrance increases the laser energy trapping into the capillary and produces higher amplitude wakefield suitable for the effective electron acceleration. The presented technique with cone entrance, increasing aperture and acceptance of the capillary, can also help to overcome the problem of pointing stability of the laser. Consistent analysis of the bunch charge (beam loading effect) influence on the energy characteristics of accelerated electrons is presented. First self-consistent simulation results obtained by the code LAPLAC for the new scheme of the low energy bunch injection in front of the laser pulse are obtained and analyzed.

TU-0203

Measurement of the Energy and Spectra of Light Back-scattered from Petawatt Laser Mater Interactions

I. Musgrave, E. Vernon, J. Green, R. Heathcote, K. Lancaster, C. Mendes, S. Hawkes, C. Hernandez-Gomez, D. A. Pepler (RAL)

We present the results of measurements of the back-scattered energy and spectra from laser mater interactions in the VULCAN Petawatt (10^{15}W) facility at intensities $>10^{20}$W/cm^2. With many laser facilities being designed and constructed with similar parameters to those of the Vulcan system, it is crucial to be confident that there is little risk of the laser being damaged from back-scattered light that would potentially experience gain in the amplifiers. The measurements of the energy of the backscattered light that we have made to date demonstrate a general trend for all target types; that approximately 1% of the energy generated by the laser is reflected back through the system and that the higher the energy of the laser pulse the lower the percentage of energy reflected back. The spectra of the light back scattered off the target is also presented. There is a clear signal at the laser first harmonic, there is also a smaller peak at the second harmonic (~530nm) corresponding to self-emission of the plasma. There are also features occurring between 700 to 1000nm. In conclusion we have demonstrated that the percentage of laser light back-scattered from laser mater interactions at petawatt power levels and intensities $>10^{20}$W/cm^2 is low ~1%. Suggesting that there is a low probability of damage occurring to optics due to energy being reflected back through the system and then subsequently amplified. We have measured the spectra of the back-scattered light and measured peaks at the expected first and second harmonics and observed signals from 700 to 100nm.

TU-0204

Hohlraums With and Without Plastic Covered Walls Experiments on OMEGA

P. Seytor, L. Videau, F. Girard (CEA-DAM)

Several experiments using gold hohlraums recovered or not recovered with plastic liner have been shot at OMEGA facility in February 2007. The experiments have been modeled by the 2D hydrodynamic radiative code FCI2. Two kinds of laser pulse shape have been used: ALPHA501P (picket + 1ns square) and SG1018 (1ns square). The experimental radiative temperature and the soft X-ray flux measured with DMX and DANTE detectors are then compared to the outputs of post-processed simulations. Numerical results are in agreement with the data for both configurations and demonstrate the advantage of a liner from wall expansion.

TU-03 — Tuesday 2nd parallel session

Equation of State of Warm Dense Hydrogen at Megabar Pressure Range

V. Gryaznov (IPCP RAS) I. Iosilevskiy (Moscow IPT)

Experimental results presented more then 10 years ago for deutherium compressed by laser-generated shock waves have attracted attention of researchers to thermodynamics of hydrogen of megabar pressures. Recent experiments provided with Z-mashine in Sandia and those on shock and isentropic explosively driven compression in Sarov give new important information for development of thermodynamic theory for dense partially ionized hydrogen. Improved model for equation of state (EOS) of warm dense hydrogen is developed in frames of 'chemical picture'. Hydrogen is considered as multi-component strongly interacted mixture of atoms, molecules, ions and electrons. Intense short-range repulsion of neutral particles is presented in frames of soft sphere model. Parameters of interaction potentials for atoms and molecules are chosen in accordance with non-empirical atom-atomic approximation (E. Yakub). Modified pseudopotential model (I. Iosilevskiy) is used for Coulomb corrections. Partial degeneracy of electrons is taken into account also. At low-temperatures the model is in satisfactory agreement with experimental data on room-temperature isotherm. High-temperature behaviour of the model is examined by comparison with a whole collection of recent experimental data on shock compression of solid and liquid deuterium as well as for pre-compressed gaseous deuterium. The additional test for the model is comparison of pressure-density dependence of quasi-isentropically compressed deuterium with latest experimental data from Sarov. Present theoretical model proved to give satisfactory agreement.

Laser Beam Reflection from Shock Waves in Xenon

V. Mintsev, Yu. Zaporoghets, V. Gryaznov, V. E. Fortov (IPCP RAS) H. Reinholz, G. Röpke (U Rostock)

Results of the first experiments on polarized reflectivity of the laser beam from xenon plasma generated by powerfull shock waves are presented. The study of polarized reflectivity properties of the plasma was accomplished within the range of plasma densities ρ= 2-3.2g/cm^3, pressures up to P$\sim$18GPa and temperatures up to T$\sim$3$\cdot$10^{4}K under conditions with strong Coulomb interaction (the nonideality parameter up to $\Gamma\sim$2.0). We used a dynamic method to generate a strongly non-ideal plasma, based on compression and irreversible heating of the gas in front of a high-power ionizing shock wave. The variation of density and electron concentrations of the plasma was achieved by changing the initial gas pressure. To measure the dense xenon plasma polarized reflectivity coefficient, the pulsed $Y_3Al_5O_{12}$:Nd^{3++} KTP laser system with electro-optical shutter based on DKDP crystal and higher-order mode suppression of the laser radiation was used. For determination of the equilibrium properties of explosively driven plasma, appropriate gas dynamics calculations were carried out. The thermodynamic model of the plasma takes into account Coulomb interaction in frames of Debye approximation in grand canonical ensemble and the short-range repulsion of heavy particles – within the soft spheres model. The integration of Maxwell equations are based on an interpolation formula for DC conductivity, obtained from a systematic quantum statistical treatment of different limiting cases.

TU-0303

Laser Plasma Created in a Gas Puff Target as an Efficient EUV Source for Different Applications

B. Bartnik, H. Fiedorowicz, R. Jarocki, J. Kostecki, R. Rakowski, M. Szczurek (IOE-MUT Warsaw)

Interaction of intense laser pulses with matter results in creation of hot dense plasma. Such plasma emits radiation in different wavelength ranges depending on laser parameters and material of a target. A good solution is a gas puff target, formed temporary into a vacuum chamber, synchronously with a laser pulse. In this paper a laser-plasma EUV source based on a double stream gas puff target is presented. The target was irradiated with 4ns Nd:YAG laser pulses of energy 0.8J and 10Hz repetition rate. The target was created by pulsed injection of a high Z gas into a hollow stream of helium using an electromagnetic valve system equipped with a double nozzle setup. It makes possible to focus a laser beam in the high density region of gas far away from the nozzle outlet and achieve an efficient EUV production without degradation of the nozzle. The source was equipped with two type of collectors. One of them was a grazing incidence mirror, the second one was an ellipsoidal multilayer mirror. The grazing incidence mirror allows to collect radiation in a wide spectral range while the Mo/Si multilayer mirror was designed to reflect radiation in relatively narrow wavelength range centered at 13.5nm. The source was proposed for different applications. One of them was micromachining of polymers by direct photo-etching. The second possible application is investigation of band structures of solids using fluorescence in EUV range. The source can be also used for EUV microscopy with the Mo/Si ellipsoidal mirror as a collector and a zone plate as a magnifying lens.

TU-0304

Tuning High-Order Harmonics for Injection Seeding X-Ray Laser Pumped by PHELIX Laser

J. Seres (JM-U Würzburg) D. Zimmer, D. Hochhaus, B. Ecker, T. Kühl (GSI, JG-U Mainz) C. Spielmann (JM-U Würzburg, FS-U Jena)

The application of X-ray lasers is restricted due to their low spatial coherence, originating from the lack of a resonator. The coherence can be substantially improved by injection seeding of the X-ray laser with a fully coherent X-ray beam. So far the only spatially coherent X-ray sources are based on laser driven high-order harmonic generation. Efficient seeding of the X-ray laser requests a spectral matching between the harmonics and the X-ray laser wavelength. However, the wavelength of harmonic lines is fixed and an odd multiple of the laser frequency and the fundamental laser wavelength is not tunable in Nd-based amplifier systems as the PHELIX. Here we present the first results of the detailed investigation of the conversion efficiency and tuning range of the harmonics by varying the pressure and intensity in the harmonic source. We will also show which X-ray laser lines in the 18-26nm spectral range will coincide with the tuned harmonics. The number of possible X-ray laser schemes can be substantially increased by using a two color laser as driver.

TU-04 — Tuesday 3rd parallel session

Experimental Study on Meteorite Impacts Through Laser Produced Craters

TU-0401

T. Desai (U Milano, NRIAM Bangalore) D. Batani, M. Bussoli, A. Villa, R. Dezulian, H. C. Pant (U Milano) E. Krouský (PALS)

High power lasers have emerged as a potential tool for exciting laboratory astrophysical research and prospectives are expanding. In this talk we discuss laser application to planetary events like meteorite impact craters. Meteors are left out material during the formation of our solar system. Although meteorite impact means death of the meteorite, the impact craters reveal valuable information about the existence of our solar system. Our earlier experimental results on craters showed similar shapes and contours to that of natural craters due to meteorite impact and this logic has initiated our interest in meteorite impact craters. We have experimentally studied the laser produced craters using natural-granite and aluminum as targets and irradiated using the laser facilities under different experimental conditions. Crater dimensions and contours of the laboratory craters were measured by adopting SEM, FIB, Laser confocal microscope etc. We have observed two types of laboratory craters viz. simple crater which are circular and bowl shaped depressions, and intricate structures resembling complex craters with central up-lift similar to large meteorites impact on earth and other planets in our solar system. We have corroborated experimental results using 2-D Multi simulations which interestingly predict the possibility of generating complex craters due to laser ablation. Mathematical modelings using two different semi-empirical approaches have also been done to understand the formation of craters. Details of the experimental results will be discussed.

Collisionless Laboratory Astrophysics at the Large Plasma Device

TU-0402

C. Niemann, C. Constantin, E. Everson, D. Schaeffer, P. Pribyl, A. Collette, S. Tripathi, S. Vincena, N. Kugland, W. Gekelman (UC Los Angeles) R. Presura, S. Neff, C. Plechaty (UN Reno)

Many situations occur in space in which a dense plasma expands into an ambient magnetized plasma that supports Alfven waves (e.g. supernova remnants, coronal mass ejections, meteor impacts, etc.). We will present experiments on the interaction of an energetic laser-produced plasma with a large magnetoplasma. Laser intensities in excess of 10^{13}W/cm^2 from a high-energy laser (>20J at 1064nm in 5ns) produce an ablating plasma plume with an expansion velocity of several 100km/s. Prior to the laser pulse an ambient He-plasma with a length of 18m and a diameter of 50cm (the Large Plasma Device at UCLA) is created at a density of $2{\cdot}10^{12}$cm^{-3} and a temperature of 5eV in an axial magnetic field of 600G (v_A = 460km/s). The magnetohydrodynamic response was measured with an array of magnetic pickup coils. We observe large amplitude Alfven waves radiated from the laser-produced plasma. The ultimate goal of these experiments is to investigate processes relevant to collisionless shocks at scale-lengths and time scales previously inaccessible in laboratory experiments.

TU-0403

Laser Ion Acceleration Studies at TUD and GSI

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The irradiation of μm-thin foils with intense, short laser pulses leads to the acceleration of protons from hydrocarbon contamination layers at the rear side of the target. This generation of short-pulsed, MeV ion beams could be the next generation of compact, high-intensity particle accelerators e.g. for radiation oncology or for high-energy-density matter generation. However, the current understanding of this Target Normal Sheath Acceleration (TNSA) process is still very basic due to complex processes taking place during laser-matter interaction. The talk summarizes the progress of our group in the field of laser-ion acceleration over the last years. Experimentally, the proton beam optimization was studied in a series of experiments with micro-grooved targets at the Z-Petawatt laser at Sandia National Laboratories (USA), the VULCAN Petawatt laser at CLF, Rutherford Appleton Laboratory (UK), the TRIDENT laser facility at Los Alamos National Laboratory (USA), the LULI 100TW laser at Ecole Polytechnique (F) and the PHELIX laser system at GSI. Various proton-beam optimization techniques were tested and will be discussed in the talk. Furthermore, our group was the first to demonstrate the transport and focusing of laser-accelerated protons with magnetic quadrupole lenses. The micro-grooved targets in combination with radiochromic film imaging spectroscopy allow a full beam reconstruction, including the energy spectrum, divergence, source size and transverse emittance in a single shot. The experiments are supported by theoretical investigations with the collisional Sheath-Accelerated Beam Raytracing code for IoN Acceleration SABRINA, the massively parallel running 3D-PIC code PSC developed by Hartmut Ruhl, as well as a 3D Charged Particle Transfer code. The latter one allows a fast, full reconstruction of experimental data and delivers the electromagnetic fields driving the ion beam expansion.

TU-0404

Data Bases of Mean and Spectral Photon Free Path in Matter with Z<30

G. Eliseev, V. Vatulin (RFNC VNIIEF)

VNIIEF is regularly performing experiments on the ISKRA-5 laser facility with targets for measuring photon free paths in different materials. Numerical simulations of the experiments are carried out using mean and multi-group photon free path, calculated using the PERST, MIXER, LEDCOP Code and those taken from the Opacity Project data base. The dependence of the Rosseland mean free paths on the atomic numbers has the oscillatory character. Such dependences can help to choose the converters chemical composition in the controlled fusion targets.

TU-05 — Tuesday 2nd plenary session

The PHELIX Facility: Operation with Pulses of Pico- and Nanosecond Duration

K. Witte, A. Blažević, C. Bruske, S. Borneis, U. Eisenbarth, J. Fils, S. Götte, T. Hahn, T. Heßling, D. Javorkova, F. Knobloch, M. Kreutz, S. Kunzer, T. Merz-Mantwill, E. Onkels, D. Reemts, A. Tauschwitz, R. Thiel (GSI) B. Ecker, D. Hochhaus, T. Kühl (GSI, JG-U Mainz) A. Frank, A. Pelka, M. Roth, J. Schütrumpf, D. Schumacher (TU Darmstadt) B. Zielbauer (U Paris Sud)

PHELIX (Petawatt High-Energy Laser for Heavy Ion Experiments), a facility built at GSI Darmstadt, has been recently commissioned for first experiments combining heavy ion and laser beams. The dual front-end architecture of PHELIX allows versatile generation of high-energy pulses of multi-ns duration and likewise high-power pulses of sub-ps duration. Presently, PHELIX can provide 500J in the 1-15ns pulse duration regime and alternatively up to 250TW pulses of sub-ps duration. The current PHELIX layout, including both front ends, pre- and main amplifier, its performance as well as several planned near-term upgrades will be outlined. Recent experiments demonstrated successful pumping of a plasma-based X-ray laser emitting at ∼7nm whereby the short pulses were employed. In another series of experiments, ns PHELIX pulses of up to 313J and the UNILAC ion beam have been combined on a thin carbon foil target in the Z6 experimental area for the first time to study the interaction of ions with cold and hot matter (plasma). In contrast to preceding experiments with laser-heated carbon foils, carried out with the smaller and lower-energy laser system nhelix, PHELIX enables production of fully ionized carbon plasma of large extent. The result of this latest measuring campaign is shortly reviewed.

TU-06 — Tuesday 3rd plenary session

TU-0601

Supernova-relevant Experiments for the National Ignition Facility

R. P. Drake, M. J. Grosskopf, C. C. Kuranz (U Michigan) T. Plewa (Florida SU) H. Hearn (U Chicago) D. Arnett (U Arizona) J. C. Wheeler (U Texas) A. R. Miles, H. F. Robey, J. F. Hansen, B. A. Remington (LLNL)

A major aspect of the hydrodynamics during core collapse supernova (SN) explosions is the unstable processes that lead to rapid outward motion of nucleosynthesis products within the star, as it explodes under the influence of the blast wave emerging from its interior. Computer simulations alone are insufficient to address these dynamics, as they cannot access the relevant regime of hydrodynamic turbulence. Looking toward the advent of the NIF laser, which can deliver hundreds of kJ to a target, we are designing experiments to produce 3D, blast-wave-driven, multiple-interface explosions and to study the outward penetration, or mixing, that develops. Previous experiments at lower energy had a very limited ability to explore diverging or multi-interface systems. This presentation will discuss the overall plan for a multilayered, diverging Rayleigh-Taylor experiment for NIF and how it connects to the SNe, will show results of computer simulations for conceptual design, and will discuss proposed diagnostics. The simulations used CALE, a hybrid Adaptive Lagrangian-Eulerian code developed at LLNL. As we proceed toward these experiments, and toward the application of NIF not only to hydrodynamic but also to radiation-hydrodynamic problems, the codes being developed at Michigan in the Center for Radiative Shock Hydrodynamics should prove useful. We will discuss these codes and how they can apply to NIF. This research was sponsored by LLNL through contract LLNL B56128 and by the NNSA through DOE Research Grant DE-FG52-04NA00064.

TU-0602

High-Energy-Density Physics Experiments by Heavy Ions at GSI and Beyond

D. Varentsov, K. Weyrich (GSI) D. H.H. Hoffmann, J. Ling, J. Menzel, N. Müller, S. Udrea (TU Darmstadt) A. Hug (GSI, TU Darmstadt) V. E. Fortov, M. Kulish, V. Mintsev, D. Nikolaev, N. Shilkin, V. Ternovoi (IPCP RAS) A. Golubev, A. Fertman, B. Yu. Sharkov, V. Turtikov (ITEP) A. Ulrich (TU München) J. Wieser (Coherent)

Knowledge of basic physical properties of matter under extreme conditions of high energy density, and in particular, of the so-called warm dense matter (WDM), such as equation-of-state, static and dynamic electrical conductivity and opacity is of fundamental importance for various branches of basic and applied physics. Intense beams of energetic heavy ions provide a unique capability for the WDM research compared to traditional drivers [1]. Using intense ion beams, one can heat macroscopic volumes of matter fairly uniformly and generate this way high-density and high-entropy states. This new approach permits to explore fascinating areas of the phase diagram that are difficult to access by other means. In this report we discuss various physics and technical issues of the high-energy-density physics (HEDP) research with intense heavy ions beams that is being performed at GSI, as well as that is to be carried out at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt by the HEDgeHOB collaboration [2]. The results of the recent WDM experiments carried out at GSI are presented along with new developments in target and ion-beam diagnostic instruments and methods that are essential for the future experiments at FAIR.

1. D. H.H. Hoffmann, V. E. Fortov et al., Phys. Plasmas 9 /2002/ 3651
2. http://hedgehob.physik.tu-darmstadt.de

Richtmyer-Meshkov Instability in Elastic-Plastic Solids

TU-0603

A. R. Piriz (U Castilla La Mancha)

An analytical model for the linear Richtmyer-Meshkov instability in solids under conditions of high energy density is presented for the first time, in order to describe the evolution of small perturbations at the solid/vacuum interface. The model shows that plasticity determines the maximum perturbation amplitude and provides simple scaling laws for it as well as for the time when it is reached. After the maximum amplitude is reached, the interface remains oscillating with a period that is determined by the elastic shear modulus. Extensive two dimensional simulations are presented that show excellent agreement with the analytical model. The results suggest the possibility to experimentally evaluate the yield strength of solids under dynamic conditions by using a Richtmyer-Meshkov instability based technique

Equation of State of Matter at High Energy Densities

TU-0604

I. V. Lomonosov (IPCP RAS)

The knowledge of material's properties is a heart of modern physics of high energy densities. We will discuss available high pressure, high temperature data which include results of band-structure, quantum molecular dynamics and plasma theories, evaluations of the critical point, traditional thermophysical measurements, 'exploding wires' experiments, static, isentropic-compression and shock-wave experiments. The importance of experiments with laser-driven shock waves and intense beams of heavy ions will be demonstrated. The multi-phase EOS model accounting for solid, liquid, gas and plasma states, as well as two-phase regions of melting and evaporating. The quality and reliability of EOS will be illustrated for metals. The most important thermodynamic information at high energy density has been collected in the relational network data base. It includes data on shock compression, adiabatic unloading, measurements of sound velocity in shocked material, isobaric expansion and free-surface velocity profiles. These data result from 346 publications for 665 substances from 1950th years.

WE-01 — Wednesday plenary session

WE-0101

Investigations of Plasma Jet Interaction with Ambient Gases by the Multi-frame Interferometric and X-Ray Pinhole Camera Systems

A. Kasperczuk, T. Pisarczyk (IPPLM Warsaw) Ph. Nicolai, Ch. Stenz, V. Tikhonchuk (CELIA) M. Kalal, D. Klir, J. Kravarik, P. Kubes (Czech TU) J. Ullschmied (Czech IPP-AS) E. Krouský, K. Masek, M. Pfeifer, K. Rohlena, J. Skala (Czech IP-AS) P. Pisarczyk (U Warsaw)

The interaction of laser driven jets with He and Ar gas puffs was investigated experimentally by means of the three-frame interferometric system and the four-frame X-ray pinhole camera. High speed well-collimated plasma jets were generated by a defocused PALS iodine laser beam interacting with massive planar Cu targets. The PALS third harmonic (0.438μm) with a pulse duration of 250ps (full width at half-maximum) and an energy of 100J was employed in two irradiation geometries: with an incidence normal to the target surface and with an oblique one (30 deg. with respect to the target normal). The jet parameters for both angles of incidence were found to be quite similar: the jet velocity up to $7{\cdot}10^{7}$cm/s, the internal Mach number greater than 10, and the electron density above 10^{19}cm^{-3}. These jets were subsequently used for interaction studies with ambient gases when they collided with a cylindrical column of these gases (radius of 3mm, neutral atom densities varying from $2{\cdot}10^{17}$ to $8{\cdot}10^{18}$cm^{-3}, axis of the column parallel to the target surface and separated from it by 3.5mm) produced by a high-pressure supersonic gas nozzle. The results of these rather unique interaction experiments, in particular those obtained in case of the oblique incidence geometry (employed to minimize the heating laser beam influence on these ambient gases), are presented and discussed. They show the effect of the double shock formation in ambient gases due to the ablative plasma and next the jet actions.

WE-0102

An Overview of Cryogenic Target Fabrication and Delivery in Russia

E. Koresheva (LPI RAS)

The free-standing target (FST) approach in inertial confinement fusion cryogenic target science, fabrication and delivery is under development at the Lebedev Physical Institute for more than 15 years. In this report we give an overview of the main results obtained in this area with special attention to the following issues:

1. Cryogenic target survival during the injection process: comparative results for isotropic ultra-fine fuel layers and anisotropic crystalline ones
2. Prospects and results in a rep-rate target fabrication and delivery using the FST approach
3. Cryogenic cylindrical HEDgeHOB targets fabrication, manipulation and survival
4. Other issues

WE-0103

Nanocluster Explosions and Quasi-monoenergetic Spectra by Homogeneously Distributed Impurity Ions

M. Murakami (ILE Osaka) M. Tanaka (NIFS)

A plasma expansion into vacuum and the resultant ion acceleration are studied analytically and numerically. The expansion of an initially uniform spherical plasma (consisting of a nanocluster or microdroplet) with radius R_{u0} and electron density n_{e0} is driven by the explosion of hot electrons having an initial temperature T_{e0}. A self-similar solution describes the non-relativistic expansion of a finite plasma mass with a full account of charge separation effects. Such key features as the energy spectrum, maximum ion energy, and energy transfer efficiency from the electrons to the ions are given by simple analytic formulae as a function of the normalized droplet radius, $L_u = R_{u0}/l_D$, where l_D is the Debye length. The solution predicts that impurity ions doped homogeneously in a droplet plasma are accelerated quasi-monoenergetically by the electrostatic field generated by the charge separation. The prediction is confirmed by N-body particle simulations. The origin of the monoenergetic spectrum is attributed to the spherical geometry.

Output Characteristics of an 1kJ Nd:Glass laser at KAERI

WE-0104

Ch. Lim (KAERI)

The Korea Atomic Energy Research Institute (KAERI) constructed a 1kJ Nd:Glass laser facility for high energy density plasma physics. The 1kJ Nd:Glass KAERI laser facility (KLF) delivers 4 beams with a clear aperture of 100mm. We measured the gain and spatial profiles of each amplification stage. The energy of the final 110mm disk amplifier was 250J with a beam diameter of 100mm at the nano-second regime. For a wide application of the facility, 50TW one beam line at the pico-second regime and a new front-end based on fiber laser were designed. A spherical chamber with a diameter of 1.1m was also installed for tetrahedral symmetric radiation

Target Area West: an 'Almost' New Target Area for Fast Ignitor Oriented Experiments

WE-0105

M. Galimberti, S. Bandyopadhyay, R. Bickerton, S. Blake, C. Burton, R. Clarke, B. Costello, J. Collier, V. Dubrovsky, M. Dunne, A. Frackiewicz, S. Hancock, R. Heathcote, C. Hernandez-Gomez, P. Holligan, R. J. Hooke, A. Kidd, C. John, K. Lancaster, B. Landowski, I. Musgrave, D. Neely, M. Notley, B. Parry, D. Pepler, M. Pitts, P. Rice, W. Shaikh, J. Suarez Merchan, T. Winstone, B. Wyborn (RAL)

The construction of two new big lasers for fusion, NIF and Megajoule, is pushing research to investigate more on inertial confined fusion. Alongside these two projects, a big European project has started its preparatory phase this year: the HiPER project. Whilst this big laser fusion facility is oriented at investigating the fast ignitor scheme, a facility capable of supporting strategic experiments on fast ignition is required. Following this line, at the Central Laser Facility we are upgrading one of the Vulcan laser target areas to be capable to delivering 500J on target at 10ps, combined with 6 long pulse beams up to 250J each and another 100J, 1ps pulse. This combination of laser pulses, united to the flexibilities of the target area will allow experiments to be performed on fast ignition with innovative diagnostics, like proton radiography. We report here the state of the upgrade and the commissioning that is ongoing. The first experiment is planned to start at the end of this conference.

WE-02 — Wednesday 1st parallel session

WE-0201

Laser-Petawatt-Driven High-Energy K_α X-Ray Sources: What are the Fundamental Conversion Efficiency Limits?

G. R. Bennett, A. B. Sefkow, M. Geißel, B. W. Atherton, R. P. Kensek, M. W. Kimmel, P. K. Rambo, J. Schwarz (Sandia NL) S. B. Swanekamp (NRL Washington)

Crucial to the optimum performance of laser-Petawatt (PW) high-energy X-ray imaging of inertial confinement fusion (ICF) and high-energy-density physics (HEDP) experiments on various facilities (for example, the Z-Accelerator at Sandia National Laboratories (USA), the National Ignition Facility at Lawrence Livermore National Laboratory, etc.), is the attainment of the highest possible conversion efficiency ϵ of laser PW light into $K_{\alpha 1}$ X-rays (say, 25.2712keV for Sn). To this end, we examine:

a. the electron- and proton-impact K-shell ionization cross sections for removing 1s electrons;
b. the self-generated bremsstrahlung field, around the region of interest - 25keV in this example;
c. the effect of 1s electron photo-ionization via the same self-generated bremsstrahlung field.

With such analysis, we hope to corroborate for example the measured 0.01% conversion efficiency ($K_{\alpha 1}$ and $K_{\alpha 2}$) for Sn. The talk will include results from a state-of-the-art Monte Carlo electron and photon transport code, analytical calculations, and possibly some preliminary Particle-in-Cell simulations. We ultimately hope to conceive of a higher efficiency PW-driven target concept that can be generalized to any $K_{\alpha 1}$ line, in order to help - in terms of X-ray imaging - the ICF/HEDP community as a whole.

WE-0202

Effects of Preplasma Expansion on Laser-driven Ion Acceleration

P. McKenna, D. C. Carroll, M. N. Quinn, X. H. Yuan (U Strathclyde) O. Lundh, G. G. Wahlström (Lund U) F. Nürnberg, M. Roth (TU Darmstadt) K. Markey, S. Kar, M. Zepf (QU Belfast) S. Bandyopadhyay, D. Neely, D. Pepler (RAL) D. Batani, R. Jafer, R. Redaelli (U Milano) R. G. Evans (IC London)

There is considerable interest in the use of high power, short pulses of laser radiation to produce uniquely short pulse and low emittance beams of multi-MeV ions. At the laser intensities presently available, the main ion acceleration occurs in an electrostatic sheath formed at the rear surface of a laser-irradiated target foil, by relativistic electrons accelerated through the foil from the front, laser-irradiated surface. Realization of the many potential applications of this unique ion source relies on enhancing and controlling the source and beam properties. Preplasma, produced at the front surface of the target foil, by prepulses and Amplified Spontaneous Emission at the leading edge of a high power laser pulse, plays a significant role in defining the properties of the ion beam. We report on the effects of front surface preplasma expansion on proton acceleration driven by ultraintense ($3{\cdot}10^{20}$W/cm^2) picosecond laser irradiation of thin metallic foils. The properties of the proton beam are investigated as a function of preplasma expansion, produced using separate low intensity ($<10^{13}$W/cm^2) nanosecond laser pulses, for which the intensity, spatial intensity distribution and temporal delay with respect to the ultraintense pulse are varied. Significant enhancement in proton acceleration is observed at optimum preplasma density gradients, due to increased energy absorption and self-focusing of the incident laser pulse. For very long preplasma expansion, the propagating laser pulse is observed to filament, resulting in reduced proton flux and maximum energy.

Applications of the High Intensity Short-Pulse Laser Driven ~MeV Proton Beam

M. Nishiuchi, I. Daito, M. Ikegami, M. Mori, S. Orimo, K. Ogura, A. Sagisaka, A. Yogo, A. Pirozhkov, H. Daido, H. Kiriyama, H. Okada, S. Bulanov, T. Esirkepov, S. Kanazawa, S. Kondo, T. Shimomura, M. Tanoue, Y. Nakai, H. Sasao, D. Wakai, H. Sakaki, P. Bolton, T. Tajima, S. Kawanishi (APRC/PMRC JAEA) H. Souda, T. Shirai, A. Noda (ICR Kyoto) I. W. Choi, C. M. Kim, T. M. Jeong, T. J. Yu, J. H. Sung, S. K. Lee, N. Hafz, K. H. Pae, Y.-C. Noh, D.-K. Ko, J. Lee (APRI Gwangju) Y. Oishi, K. Nemoto (CRIEPI)

A laser-driven proton beam with a maximum energy of a few MeV is stably obtained using an ultra-short and high-intensity Titanium Sapphire laser. As compared with the proton beam from the conventional accelerator, this proton beam exhibits peculiar characteristics, such as, more than 10^{13} protons per bunch are produced within a short pulse duration of ~ps at a source, resulting in a very high peak current. It also exhibits a very low transverse emittance. The proton beam has a divergence angle of ~10 degrees and energy spread of ~100%. Another interesting feature of the laser-driven proton beam is that it accompanies electrons and X-rays which produced simultaneously. Making the best use of these peculiar characteristics, many possible applications of the laser-driven proton are proposed. In order to make practical laser-driven proton beam for the applications, we carry out series of experiments, such as making imaging system with the proton, X-ray and electron beams. We have successfully obtained simultaneous imaging of the target with proton and X-ray or proton and electron beams. In the course of practical use of the proton beam for specific applications, characteristics above should be optimized based on the variations of the applications. For example, in order to apply the laser-driven proton beam for the proton irradiation system, such as used in the medical or the industrial applications, we should obtain focused or parallel proton beam. One of our plans to alter the orbits of the laser-driven protons from the planer tape target is using permanent quadrupole magnet.

WE-03 — Wednesday 2nd parallel session

WE-0301

Dynamics of Laser-induced Dielectric Breakdown

B. Rethfeld (TU Kaiserslautern) H. Krutsch, D. H.H. Hoffmann (TU Darmstadt) L. Englert, L. Haag, M. Wollenhaupt, C. Sarpe-Tudoran, T. Baumert (U Kassel)

When transparent solids are irradiated with a laser of sufficient high intensity, an electron-hole plasma may be generated, which consists of free electrons in the conduction band of the solid and holes in the valence band. Dielectric breakdown may be caused when a certain density of free electrons is reached, which can be identified with the critical plasma density. The resulting large energy transfer to the solid leads further to phase transitions and ablation, which can be monitored experimentally. In this talk we present theoretical studies on the dynamics of electrons in laser-irradiated dielectrics. We compare different models and their applicability to calculate the transient increase of free electron density. We show that the characteristic of density increase strongly depends on the temporal shape of the exciting laser pulse. Resulting effects of different pulseshapes on laser ablation are discussed and compared with experimental results.

WE-0302

The Possibility of Master Oscillator Creation of Iodine Photo-Dissociation Laser on the Base of Nd Doped YLE Crystal

N. V. Zhidkov, V. A. Krotov, E. V. Pozdnykov (RFNC VNIIEF)

The experimental results of possibility of YLF crystal application as an active medium of iodine laser master oscillator (MO) are presented in this report. The lasing wavelength is 1.3152μm. The possibility of MO spectrum control within the spectrum of iodine laser medium luminescence was researched. For the mode-locked operation the amplification in the iodine medium is near the predicted value and reached $\sim$10.

WE-0303

Limits of the Temporal Contrast for CPA Lasers with Tiled Diffraction Grating Compressors

M. Kalashnikov (MBI Berlin) A. Andreev (VSOI St. Petersburg)

Modern high field lasers develop in the direction of increasing the output energy as well as shortening pulse duration to several oscillations. Both routes are combined in the outstanding ELI project (Extreme Light Infrastructure), that recently started in EU. High energy and big bandwidth require compressors with tiled diffraction gratings. It is obvious that such compressors have potentially much higher probability for alignment errors than a conventional one. The new generation of high field lasers assumes energy in the range of a kJ and duration of several oscillations. Much higher intensity level of $\sim 10^{24}$W/cm^2 is under discussion. These conditions demand on very high requirements for the pre-pulse level (at least 10^{-14} lower than the peak intensity) and steepness of the front edge of the optical pulse. In the compressor with tiled diffraction gratings clipping of the pulse spectrum on each of the diffraction gratings and slight misalignment are hardly to be canceled. Despite that high aperture of the incident beam 'smoothes' influence of errors, they result in appearance of a pedestal, pre/post pulses and broadening of the pulse duration. These effects applied to pulses of several oscillations and influence of the beam aperture will be considered in the presentation. New geometry of the compressor with tiled diffraction gratings that supports lower requirements to the accuracy of alignment of diffraction gratings and lower level of the pre-pulse will be reported.

WE-04 — Wednesday 3rd parallel session

Pressure Dependent Nonlinear Refractive Index of Inert Gases

WE-0401

K. Osvay (MBI Berlin, U Szeged) A. Börzsönyi, A. P. Kovács (U Szeged) Z. Heiner (U, BRC Szeged) M. Kalashnikov (MBI Berlin)

In experiments and laser systems where high intensity laser beams propagate in gaseous media, the precise knowledge of the nonlinear refractive index (n_2) is essential. Namely, beam delivery of high power laser systems has to be designed so that the n_2 related effects as self-phase modulation and self-focusing should be avoided. Moreover, many applications of modern laser spectroscopy can benefit from them, like white continuum generation, filamentation and even pulse compression. Apart from one measurement made in the pressure range of 0.2 and 3 bars for N_2, O_2 and air, there is no comprehensive data set for the dependence of n_2 on pressure over more orders of magnitude. In this paper we report on a direct measurement of pressure dependent nonlinear refractive index of Ar, He, Kr, N_2, Ne, Xe, and air. In the experiment a non-collinear Mach-Zehnder interferometer with an arm length of 9m was built into a vacuum chamber. The unfocused incoming pulses of 1cm beam diameter, 1mJ energy and 40nm bandwidth were split unequally, resulting in an intensity ratio of 1:10 between the reference and sample arms. Having balanced for the intensities of the interfering pulses just before leaving the vacuum chamber, the superpositioned pulses were sent onto the input slit of an imaging spectrograph. By varying the pressure of the gases from 0.05 mbar to 1 bar, the change of nonlinear refractive indices has been determined from the spectrally and spatially resolved interferograms. Their absolute values at atmospheric pressure vary from 1.34 (He) to $126.6 \cdot 10^{-19}$ cm^2/W (Xe).

Shape of the Titanium K_α-Line Produced by Relativistic Laser-Plasma Interactions

WE-0402

U. Zastrau, T. Kämpfer, I. Uschmann, E. Förster (FS-U Jena) P. Audebert, E. Brambrink, M. Koenig (LULI) A. Sengebusch, H. Reinholz, G. Röpke (U Rostock) E. Kroupp, E. Stambulchik, D. Fisher, V. Bernshtam, L. Weingarten, Y. Maron (WIS Rehovot)

Electrons can be accelerated up to GeV energies by ultra-short laser pulses at intensities $>10^{19}$W/cm^2. In solid targets, as a result of non-linear absorption and plasma heating mechanisms, ultra relativistic electron currents are created which are predicted to induce very strong electric and magnetic fields, plasma polarization shifts and other high-energy density effects which are important in the context of inertial confinement fusion. Measuring plasma parameters requires diagnostic with high spatial, temporal, and spectral resolutions. Furthermore, detailed control of the laser properties such is necessary to obtain high reproducibility. The exciting physics of this process can be investigated by studying the characteristic X-ray emission of ions located inside the strong electron current. The experiment was performed at the LULI 100TW laser, providing up to 14J in 330fs in a 8μm focal spot on thin titanium foils with thicknesses from 2 to 25μm. Single-shot spectra of the K_α-doublet emission (4.5keV) were detected using a toroidally bent GaAs crystal X-ray spectrometer, achieving 0.2 eV spectral and 13.5μm 1-D spatial resolution. Higher ionic states yield satellite lines on the blue wing of each line, from which the plasma composition can be inferred. According to recent calculations applying a self-consistent ion sphere model, the lines are additionally shifted due to polarization of the surrounding plasma. Reabsorption is taken into account. Finally, Doppler, Stark and Zeeman effect can play a role.

WE-0403

X-Ray Spectroscopic Study of Plasma Produced in Laser Irradiated Porous Low-Density Targets with High-Z Dopants

V. Gavrilov, I. N. Burdonskiy, I. K. Fasakhov, V. V. Gavrilov, A. Yu. Goltsov, N. G. Kovalskii, V. M. Petryakov, M. V. Putilin (TRINITI) E. P. Ivanova (IS RAS)

In experiments on Mishen facility (Nd-laser, wavelength 1.054μm, pulse duration 3ns, intensity 10^{13}-10^{14}W/cm^2) the porous low-density (2-10mg/cm^3) targets of agar doped with high-Z elements were irradiated. The soft X-ray spectra (wavelength 0.5-20nm) of multicharge ions from produced plasma were recorded with the crystal and grazing incidence spherical grating spectrographs of high spectral and spatial resolution. The observed spectra were compared with those obtained in experiments on irradiation of solid-density high-Z element samples and with the results of numerical simulation as well. The acquired data are of practical interest for indirect-drive ICF target designs. Moreover, in experiments with Sn-doped porous targets the conditions were searched providing the plasma with enhanced concentration of Ni-like Sn ions being of interest for lithography. This work was supported by the Russian Foundation for Basic Research (Project No. 08-02-00814).

TH-01 — Thursday 1st plenary session

The Design for 100fs X-ray Streak Camera

B. Li, R. Pattathil, D. Neely (RAL) G. Gregori (RAL, U Oxford) P. Jaanimagi (RAL, U Rochester) F. Read (CPO) R. Prasad (QU Belfast) L. Pickworth (RAL, IC London) M.-I. Benetou (RAL, UC London) P. Lau, J. Lynn (U Oxford)

Streak cameras are perhaps the only solutions to investigate ultrafast laser-matter interaction by temporally resolving ultrashort plasma emissions, especially in X-ray regimes. However, existing streak cameras after decades of development are still restricted by limited applications (e.g. low time resolution, small dynamic range, limited sensitivity). Here we present a state-of-art design of X-ray streak tube, applying a modest extraction field at the photocathode, followed by the double cylindrical deflection analyzer (DCDA) axial time-of-flight dispersion compensation electron optics to achieve the breakthrough of 100fs time resolution. Both the theoretical simulations (e.g. applying Jaanimagi model) and experimental approach (detailed engineering design along with the testing and calibration) will be presented.

Experimental Investigations of Turbulence in Pulsed-Power-Driven High-Energy-Density Plasmas.

E. Kroupp, D. Osin, A. Starobinets, E. Stambulchik, V. Fisher, V. Bernshtam, L. Weingarten, Y. Maron, E. Stambulchik (WIS Rehovot) I. Uschmann, E. Förster (FS-U Jena)

We describe the development of experimental spectroscopic methods for the investigation of the evolution of turbulence in both imploding and stagnating plasmas that are subjected to acceleration and compression under pulsed, intense magnetic fields. The main experiments are performed in the z-pinch configuration, where a cylindrical annular plasma (diameter 4cm and L≈1.5cm) implodes under an azimuthal magnetic field produced by a current pulse (1MA rising in 500ns) driven axially through the plasma. Turbulence in such a plasma may develop during the implosion phase ($n_e \approx 10^{18}$–10^{19}cm^{-3}, $T_e \approx 5$–50eV, radial velocity $\approx 2 \cdot 10^7$cm/s), and during the stagnation ($n_e \approx 10^{21}$cm^{-3}, $T_e \approx 250$eV, Z(neon)≈9), where the plasma assembles on axis, and the plasma kinetic energy gained in the implosion is transformed to heat and to an intense radiation pulse. A formidable difficulty in investigating turbulence is that even if the total ion kinetic energy is observed (from line-emission Doppler shapes), the discrimination between the thermal and turbulent components in the ion velocity distributions is nearly impossible (since usually turbulence also yields Gaussian-like Doppler line shapes). For such discrimination we utilize observations of the ion-kinetic-energy loss rate to the colder electrons, thus together with energy balance considerations give bounds on the thermal fraction of the total ion-kinetic energy.

Balancing Between Structured-Target Imprint and Smoothing in the Laser Experiments with Condensed Layers of 1/4th Critical Plasma Density

N. Borisenko (LPI RAS)

Comparative analysis of different targets under different irradiation conditions is fulfilled provided that the beam-plasma interaction is close to 1/4th of the critical plasma density. The subsequent experimental studies give information on the basic behavior in plasma, optimization prospects and applicability of the low-density microheterogeneous elements for IFE, laboratory astrophysics and laser interaction with matter

TH-0104

Generation of Energetic Radiation with Z-Petawatt

M. Geißel, G. R. Bennett, A. D. Edens, M. W. Kimmel, P. R. Rambo, J. Schwarz, D. B. Sinars, I. C. Smith, B. W. Atherton (Sandia NL)

Sandia's Z-Backlighter Facility has been operating the Z-Beamlet laser successfully for several years now, leading to profound progress in the understanding of capsule compression and z-pinch dynamics with the Z-Accelerator pulsed power facility. To enhance temporal resolution and to increase the backlighter's photon energies, Sandia has built the Z-Petawatt laser, which is able to deliver 500J within a 500fs pulse. This presentation will describe the upgraded facility and report on experiments at the 100TW (50J) level that focused on the generation and optimization of energetic X-rays and protons, which will be useful as diagnostic tools or drivers in Sandia's High Energy Density Physics mission.

TH-0105

Development of 10PW OPCPA Capability for the Vulcan Laser Facility

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We present the progress that has been made in developing 10PW capability for the Vulcan laser. These pulses will have focused intensities $>10^{23}$W/cm^2 which represents orders of magnitude increases in intensity currently available and will be generated using the technique of optical parametric chirped pulse amplification, OPCPA. This will be achieved by delivering pulses with energies greater than 300J and pulse durations less than 30fs. We will discuss the overall amplification architecture that we are developing to achieve these powers and the results of steps we have undertaken to mitigate against the risks of this approach and secure funding for the second phase. These experiments include progress towards generating high contrast μJ level pulses at 900nm with a bandwidth to support <30fs pulses and studies of the parasitic fluorescence during the joule level amplification. There will be three stages of amplification that fall into two phases of the project. The first stage of amplification is to generate μJ seed pulses. These pulses will then be stretched for amplification to the Joule level before final amplification to +300J before compression. The first two stages of amplification will form a new and independent front-end for the Vulcan laser and comprise the first phase of the project. The third stage of amplification is the second part of the project and will require an increase of the capabilities of the existing glass amplifier chain by the addition of further amplification stages to take the output of two beamlines to +1.5kJ at 1053nm.

TH-02 — Thursday 1st parallel session

Interaction of Intensive Laser Radiation with Matter on Installation KANAL-2

TH-0201

A. A. Fronya, D. B. Charelishvili, M. V. Osipov, V. N. Puzyrev, A. T. Sahakyan, A. N. Starodub, B. L. Vasin, O. F. Yakushev (LPI RAS)

The results of laser-matter interaction investigations are presented. These investigations were carried out on powerful laser installation KANAL-2, that consist of neodymium glass laser with controllable function of mutual coherence (pulse duration 2.5ns, spectral radiation width 2.4 or 4.2nm, output laser energy from 30 to 100J, power flux density of heating radiation on target 10^{13}-10^{14}W/cm^2) and interaction chamber with complex of diagnostic devices allowed to register the parameters of laser radiation and plasma with temporal (10ps), spectral (0.05nm) and spatial (12μm) resolution. The used diagnostic schemes enables to work in wide spectral (0.4-1.1μm) and registration angle range ($\sim$90 degrees). Experiment results of laser radiation interaction with different target and its qualitative description are reported. Metal foils and volume-structured materials with density 4.5 and 9 mg/cm^3 were used as the targets. Analysis of experimental data showed, that reflected energy part makes $\leq$5% from incident radiation energy for all types of used target, plasma electron temperature is $\sim$0.5-1.2keV. Scattered radiation on frequency ω_0 concentrates practically in heating radiation aperture of laser beam, scattered radiation on frequency $2\omega_0$ spread more diffusely in space. Intricate structure of plasma radiation spectra on basic frequency and harmonic frequencies indicates of plasma oscillation excitation in area of electron density $n_e<n_c$, that points out existence of different types of nonlinear processes under laser-matter interaction.

Enhanced Ion Acceleration using High Contrast Laser Pulses on the Astra Laser System.

TH-0202

P. Foster, D. Neely, S. Hawkes, A. Robinson, C. Spindloe, M. Streeter (RAL) D. C. Carroll, P. McKenna, G. G. Wahlström (U Strathclyde) B. Dromey, S. Kar, M. Zepf (QU Belfast) F. Lindau, O. Lundh, A. Persson (Lund IT)

Laser-accelerated proton beams have numerous potential applications ranging from fundamental physics to medicine. Controlling and enhancing their brightness, energy etc is an extremely active area of current research. The work presented here details the results of a recent experiment exploring laser interactions with ultra-thing foils at high-contrast, up to 10^{10}, over an intensity range from 10^{16} to 10^{19}W/cm^2. Interesting scaling relations for the effect of defocusing, laser energy and target thickness on the maximum proton beam energy and total flux is presented. Comparisons are made between ion beam spatial profile data and angularly resolved ion spectra. This work was carried out using the Astra Laser, at the Rutherford Appleton Laboratory, which is a high-repetition rate Ti:Sapphire laser system. To make use of the high-repetition rate, ultra-fast scintillator spectrometers were implemented and details of the calibration method and results are also presented here. This new detection method offers immediate feedback enabling the online optimisation of interaction conditions.

High Temporal Contrast Front End for High Field Lasers

TH-0203

H. Schönnagel, M. Kalashnikov, K. Osvay (MBI Berlin)

The crucial issue of the construction of PW class lasers is to achieve a temporal contrast higher than 10^{10}, which is basically determined by the quality of the mJ level pulses coming from the front end of the laser system. To improve the performance of a front end, several new ideas have been recently developed. So far these techniques have been implemented individually, resulting in a maximum temporal contrast of 10^{10}. In our approach we combine together the ideas of multipass amlification, double chirped pulse amplification (DCPA), negatively-positively chirped pulse amplification (NPCPA) and cross-polarised wave generation (XPW), so that a temporal contrast exceeding 10^{12} is expected. The pulses from a broadband femtosecond oscillator are negatively stretched in a multiple-prism compressor, and then amplified in a 9-pass, astigmatically compensated double-confocal multipass amplifier pumped at 50Hz by a laser with high pulse-to-pulse stability. As a result, pulses with 40nm bandwidth, a strongly blue-shifted peak wavelength of 785nm, and 1mJ energy of an rms stability of 1.7% leave the amplifier. After compression in bulk glass and chirped mirrors, the pulses are temporally filtered using XPW generation in a vaccum chamber. Taking into account the efficiency and the cubic intensity dependence of the XPW process, pulses with sub-mJ energy and temporal contrast of 10^{12} at least, are expected. Contrast issues associated with possible pre-pulses on a ns scale as well as a finite steepness of the leading pulse front will also be considered.

TH-0204

Generation of Plasma Flare in the Atmosphere using a Dual Femtosecond/Nanosecond Laser Pulse

Z. Henis (Soreq RC) G. Milikh, D. Papadoupolos (U Maryland) A. Zigler (Hebrew U)

Generation of powerful radiation sources at remote location in the atmosphere, using a dual femtosecond/nanosecond laser pulse is suggested. The plasma channel in the wake of the filament formed during intense ultra short pulse propagation in the atmosphere serves as seed electrons that absorb energy delivered by a long pulse laser, inducing further ionization and significant air heating. The increase in energy density leads to enhancement of radiation emitted by the plasma channel of several orders of magnitude. The interaction of the dual laser pulse with air and the resulting radiation emission is described by a one dimensional fluid model.

TH-03 — Thursday 2nd parallel session

X-ray diagnostic and X-ray Optics to Investigate keV-Radiation of a Laser Based High Repetition X-ray Source

TH-0301

I. Uschmann, R. Lötzsch, O. Wehrhan, E. Förster (FS-U Jena) M. Silies, H. Zacharias (WW-U Münster)

If a focussed high power short laser pulse reaching an intensity higher than 10^{15}W/cm^2 on a solid target hot electrons are accelerated to keV and even higher energies. Then a short burst of hard X-radiation is produced in the solid. Such an intense X-ray source is attractive for several applications, i.e. time resolved diffraction and spectroscopy as well as X-ray induced photoelectron spectroscopy. To provide as much as possible X-ray photons for the application experiments the plasma source has to be optimized. We present a new developed bright von Hámos spectrometer based on calibrated HOPG crystals to diagnose hard X-ray emission in the 5-15keV range of a high repetition plasma source. Further we show the design, the preparation and the test of toroidally bent crystals used to focus as much as possible photons for photoelectron spectroscopy experiments by using Fe K_α and Cu K_α.

Exploring the Complete Temporal Evolution of Strong and Transient Fields with Proton Imaging

TH-0302

T. Sokollik, M. Schnürer, S. Steinke, P. V. Nickles, W. Sandner, M. Amin, O. Willi (MBI Berlin) T. Toncian (HH-U Düsseldorf) A. Andreev (VSOI St. Petersburg)

Laser accelerated ion beams become more and more promising for possible applications in material-research, medicine, or for injection into conventional ion accelerators. Aside from laser parameter scaling being studied previously a strong interrelation to the target system is given. Advantageous properties are theoretically predicted for different types of targets. We found that the dynamics of strong fields associated with intense laser interaction of thin foils cover spatial extensions of several millimeter and temporal durations of picoseconds up to nanoseconds. We developed proton imaging techniques which allow a continuously tracing of the complete temporal evolution of the field in one spatial dimension. Complementary two dimensional snapshots at different times of the field evolution are done by using a similar pump probe approach. These investigations are important for a better understanding of high field phenomena, the transport phenomena of energetic electrons and the ion acceleration process in order to optimize and manipulate the generated ion beam for future applications. Acknowledgement: This work was partly supported by DFG - Sonderforschungsbereich Transregio TR18 and GRK 1203.

On the Possibility of Axial Configuration Spontaneous Magnetic Field Observation in Laser Plasma

TH-0303

P. V. Konash, I. G. Lebo, O. A. Zhitkova (Moscow TU)

Generation of spontaneous magnetic fields (SMF) in laser-produced plasmas is a well-known phenomenon. The generation of axial configuration SMF (i.e. the field directed along the axis of target normal or the axis of laser beam) has been discussed in [1]. It is extremely difficult to observe such axial (or poloidal) fields using the traditional optical technique based on Faraday effect, because the probe laser beam encounters an opaque target. We have proposed a new approach to SMF observation using the electron bunch scattering in laser plasma [2]. We have demonstrated the results of 3D numerical simulations of electron beam scattering by the SMFs and discussed the parameters of experiments.

1. R. Dragilla. Phys. Fluids 30, 3, 925 /1987/
2. P. V. Konash, I. G. Lebo. Quantum Electronics 36, 8, 767 /2006/

Mathematical Modeling of Power Laser Pulse Interaction with Porous Targets

I. G. Lebo, A. Lebo (Moscow TU)

We have proposed a some physical-mathematical model of power laser pulse interaction with low density porous targets [1]. We have carried out the simulations of the "hydro-thermal wave" expansion in laser plasma by using 2D Lagrange code ATLANT [2]. Good agreement between numerical results and experinemtal data have been obtained. Using this model it is possible to explain some challenging phenomena, which have been observed at PALS experiments. For example, it has been observed a weak irradiation at t=0.15-0.2ns and bright irradiation in optical spectrum with time delay 1-1.5ns after laser pulse closing from rear side targets. The investigation has been supported by RFBR, project #08-01-00291a.

1. Lebo I. G., Lebo A. I. Matematicheskoe Modelirovanie, 20, /2008/ – in print
2. Lebo I. G., Popov I. V., Rozanov V. F., Tishkin V. F. Journal of Russian Laser Research, /1994/, 15, pp.136-143

TH-04 — Thursday 3rd parallel session

Investigation of X-ray Opacity in Al and Ge in Experiments at the Laser Facility Iskra-5

TH-0401

N. A. Suslov, V. I. Annenkov, M. A. Barinov, S. A. Bel'kov, A. V. Bessarab, S. V. Bondarenko, V. F. Ermolovich, S. G. Garanin, R. V. Garanin, G. G. Kochemasov, A. G. Kravchenko, V. A. Krotov, V. P. Kovalenko, S. I. Petrov, A. V. Pinegin, O. O. Sharov, N. V. Zhidkov (RFNC VNIIEF)

The results of experiments on investigation of X-ray opacity in Al and Ge samples heated up to 30-50eV are presented. Target construction, measurement setup and experiment conditions are described. The results of opacity measurements in Al and Ge in the range h$\nu\approx$1.2-1.6keV measured by X-ray absorption spectroscopy are presented. The results of theoretical modeling and its comparison with experimental ones are presented.

2D Modeling of Field Ionization Role in Ion Acceleration from Thin Foils Irradiated by Laser Pulse of 10^{21}W/cm^2 Intensity

TH-0402

I. Glazyrin, V. Yu. Bychenkov, A. V. Karpeev, O. G. Kotova, V. A. Lykov, S. I. Samarin, A. N. Slesareva, E. Yu. Smirnov (RFNC VNIITF)

Ionization of matter under the interaction of femtosecond Ti-Sa laser pulse of 10^{21}W/cm^2 intensity with Al foil of 0.1μm thickness is determined by the laser electric field. Electrons appeared after the ionization are anisotropic in momentum space and despite of developing Weibel instability, which makes electrons distribution function close to the isotropic one with time, the effect of photoionization qualitatively changes the laser-target interaction in comparison with the preformed plasma target case (e.g., due to the laser prepulse). Numerical simulations with 2D hybrid code (PIC approach for fast electrons and MHD for thermal particles) have been performed to study the role of laser field ionization of Al target. It is shown, that efficiency of energy transform from laser field to electrons and ions is much higher when field ionization effect is taken into account, the depth of skin-layer and electrons energy are increased. Protons are accelerated up to high energies due to charge separation effect, in the case of field ionization the number of ions with the energy in the range of 20-100MeV is considerably higher than the number of ions in the case of given plasma slab. This work was supported by the International Science and Technology Center, Project No. 2289.

Surface plasmon enhanced electron acceleration with few-cycle laser pulses

TH-0403

P. Dombi, P. Racz, G. Farkas (SZFKI Budapest) S. E. Irvine, A. Y. Elezzabi (U Alberta)

It was shown recently that surface plasmonic fields that are induced by relatively low-energy femtosecond laser pulses are capable of accelerating electrons to keV energy levels. This novel ultrafast electron source configuration has further intriguing properties when the interaction is induced by few-cycle laser pulses. In this case the carrier-envelope phase of the pulses is also expected to play an important role in the process. We performed the numerical investigation of this phenomenon the results of which are presented together with first experimental studies carried out in the few-cycle regime.

Investigation of Intense Ion Beams Interaction with Matter and Dynamic Processes in Irradiated Targets.

V. V. Vatulin, S. V. Aksenov, I. M. Belyakov, A. S. Gnutov, G. M. Eliseev, L. Z. Morenko, O. A. Vinokurov, N. V. Zhidkov (RFNC VNIIEF)

Penetration of charged particles through matter is accompanied by various processes of interaction with elementary particles, nuclei, ions, atoms. The character and the effect of these interactions depend on the type, energy and intensity of the particle beam and on the type, state, density, composition and size of the target. This report presents the some results of the calculation and theoretical investigations of laser and ion beam interactions with different targets.

TH-05 — Thursday 2nd plenary session

Phase-coherent Soft X-ray Lasers at Wavelengths down to 13.2nm

J. J. Rocca, Y. Wang, F. Pedacci, M. Berrill, B. Luther, D. Alessi, D. Martz, B. Reagan, F. Furch, E. Granados, F. Brizuela, P. Wachulak, M. C. Marconi, C. S. Menoni (NSF CEUST)

There is keen interest in generating intense fully coherent soft X-ray beams for new scientific and measurement applications. We will discuss recent progress in the development and application of plasma-based table-top soft X-ray lasers. This includes the demonstration of table-top soft X-ray lasers with essentially full spatial and temporal coherence operating at wavelengths down to 13.2nm. Gain-saturated soft X-ray laser pulses were produced in dense laser-created plasmas, by amplifying high-harmonic seed pulses in transitions of nickel-like ions. These compact soft X-ray lasers offer new scientific opportunities in small laboratory environments.

TH-06 — Thursday 4th parallel session

TH-0601

The Use of EUV Lasers for Laser-Plasma Probing

G. J. Tallents, N. Booth, M. H. Edwards, L. Gartside, H. Huang, A. K. Rossall, E. Wagenaars, D. S. Whittaker, Z. Zhai (U York)

Saturated extreme ultra violet (EUV) lasers of wavelength 12-20nm can be produced by <1J of infra-red laser pumping energy. This talk will illustrate how such EUV lasers can be used to probe hot plasmas created with large laser systems. The use of EUV lasers to measure plasma opacity and the rate of infra-red laser ablation will be specifically discussed.

TH-0602

Development and Multidisciplinary Applications of High-Energy Soft X-ray Laser

T. Mocek, B. Rus, M. Kozlová, J. Polan, P. Homer, K. Jakubczak, M. Stupka, D. Snopek, J. Nejdl, J. Chalupský, V. Hájková, L. Juha (PALS) M. H. Edwards, D. S. Whittaker, G. J. Tallents, P. Mistry, G. J. Pert, N. Booth, Z. Zhai (U York) M. Fajardo (IST Lisbon) P. Zeitoun (LOA-ENSTA) R. W. Lee, M. E. Foord, H. Chung, S. J. Moon (LLNL)

We review development of multimillijoule X-ray lasers and applications of these laboratory sources carried out at the PALS facility. A backbone of this research programme is the Ne-like Zn laser at 21nm providing 10mJ pulses which is currently the most energetic coherent radiation source in the soft X-ray spectral region. Recent results include X-ray laser probing of dense plasmas, generation of warm dense matter by volumetric heating of thin foils by focused X-ray laser, precise measurements of laser ablation rates, and single-shot ablative microstructuring of solids.

TH-0603

3D Time-dependent Modelling of the Amplification of an Injected X-UV Line by an OFI Plasma

G. Maynard, A. Boudaa, B. Cros, B. Robillart, F. Wodja (LPGP) J. P. Goddet, S. Sebban (LOA-ENSTA)

Recent experiments have been performed at LOA to study the properties of a pulsed soft-X-ray laser (XRL) beam produced by seeding a high-order harmonic beam in an optical field ionized plasma amplifier. For these experiments several diagnostics have been implemented to get accurate measurement of the XRL parameters, in particular regarding spatial and temporal coherence of the beam and also its phase fluctuation. To analyse the experimental results, we have developed a 3D time-dependent numerical code COFIXE-3D that describes, using Maxwell-Bloch equations, the transport and amplification of an injected soft-X-ray line through the plasma amplifier. Special emphasis has been given to spatial filtering and to saturation effects at ultra-high intensities. Concerning spatial filtering, a direct comparison with experiment on both intensity and phase fluctuation has been obtained by working directly on the data of the X-ray Hartmann sensor. Good agreements between experiment and theory have been obtained, in particular in demonstrating that the plasma amplification induces a strong reduction of the phase fluctuation. Concerning the time variation of the XRL beam, we show that strong oscillations appear above a given threshold leading to higher maxima in intensities.

1. J. Ph. Goddet et al., Optics Letters 32, 1498 /2007/

TH-07 — Thursday 5th parallel session

Impact-driven Shock Waves and Thermonuclear Neutron Generation

TH-0701

S. Yu. Gus'kov, N. N. Demchenko, I. Ya. Doskoch, V. B. Rozanov (LPI RAS) H. Azechi, M. Murakami, T. Sakaiya, T. Watari (ILE Osaka) N. V. Zmitrenko (IMM RAS)

Impact-driven shock waves, thermonuclear plasma and neutron yield are investigated. The results of 2D numerical simulation as well as Gekko/HiPER laser experiment [1] on a collision of laser-accelerated disk-projectile with heavy target both (CD)n-material containing are discussed. Two-temperature model of non-equilibrium plasma created by impact-driven shock waves due to a collision of laser-accelerated plane projectile with a massive target is developed and used for analysis of numerical and experimental results. Two effects are discovered significantly influence on plasma parameters and neutron yield. First of them relates to a formation of pre-impact state of projectile and represents the decreasing of projectile's density due to thermal expanding of matter through a free boundary of projectile during the period of laser-driven acceleration. Another one relates to the formation of impact-produced plasma. It is a predominant heating of ion component of plasma that leads to the existing of non-equilibrium two-temperature plasma during the period of electron-ion relaxation. The work is supported by RFFI Grant #08-02-91202-JF.

1. T. Watari, T. Sakaiya, H. Azechi et al. IFSA 2007, Kobe, Japan, FPo20, 261

Rayleigh-Taylor, Classical and Ablative Richtmyer-Meshkov Instabilities in Laser-Accelerated Colliding Foils

TH-0702

Y. Aglitskiy, N. Metzler (SAIC NRL) M. Karasik, V. Serlin, S. P. Obenschain, A. J. Schmitt, A. L. Velikovich, S. Zalesak, J. H. Gardner, J. Weaver, J. Oh (NRL Washington)

Hydrodynamic instability growth in a plasma shell which is rapidly decelerated by the shock wave reflected from the center of the imploded target is an important feature of all scenarios of laser fusion ignition. In our experiments done on the Nike KrF laser at NRL, we study instability growth at shock-decelerated interfaces in planar colliding-foil experiments. We use streaked monochromatic X-ray face-on imaging diagnostics to measure the areal mass modulation growth caused by the instability. Simultaneous streaked side-on imaging s used to follow the 1D dynamics of the collision as well as shock propagation. The mechanisms of the observed perturbation evolution depend on the location of the initial perturbation. When only the front surface of the impacted foil is rippled, a classical RM-type instability develops at the dynamically formed material interface, and its growth is stopped by the arrival of a rarefaction wave, as in the classical RM case. When the laser-driven foil is rippled, and an ablative RT instability develops while it is accelerated towards the low-density foam foil, the acceleration and the RT growth are rapidly stopped by the strong shock wave produced in the impact. The dynamics of the perturbation development that follows combines the features of

a. the heavy-to-light classical Richtmyer-Meshkov instability,
b. the oscillatory ablative RM instability, and
c. the areal mass oscillations in a rippled rarefaction wave produced by the feedout mechanism in a laser target.

Our experimental data, theoretical and simulation results will be discussed.

TH-0703

Plasmon Resonance in Warm Dense Matter

R. Thiele, T. Bornath, C. Fortmann (U Rostock)

Collective Thomson scattering with extreme ultraviolet light or X-rays is shown to allow for a robust measurement of the free electron density in dense plasmas. Collective excitations like plasmons appear as maxima in the scattering signal. Their frequency position can directly be related to the free electron density. The range of applicability of the standard Gross-Bohm dispersion relation and of an improved dispersion relation in comparison to calculations based on the dielectric function in random phase approximation is investigated. More important, this well-established treatment of Thomson scattering on free electrons is generalized in the Born-Mermin approximation by including collisions. We show that, in the transition region from collective to non-collective scattering, the consideration of collisions is important.

TH-08 — Thursday 6th parallel session

Radiative Properties of Hot Dense Plasmas and Optimizing Soft X-ray Sources for ICF Applications

TH-0801

N. Yu. Orlov (JIHT RAS)

Theoretical and experimental studies of radiative properties of hot dense plasmas that are used as soft X-ray sources have been carried out depending on the plasma composition. A brief overview of different models used to calculate the radiative opacity of hot dense plasmas is given. Important features of the theoretical model, which can be used for complex materials, are discussed. An optimizing procedure that can determine an effective complex material to produce optically thick plasma by laser interaction with a thick solid target is applied. The efficiency of the resulting material is compared with the efficiency of other composite materials that have previously been evaluated theoretically. It is shown that the optimizing procedure does, in practice, find higher radiation efficiency materials than have been found by previous authors. The optimizing method is also demonstrated for different plasma temperatures and densities. Similar theoretical research is performed for the optically thin plasma produced from exploding wires. Theoretical estimations of radiative efficiency are compared with experimental data that are obtained from measurements of X-pinch radiation energy yield using two exploding wire materials, NiCr and Alloy 188. It is shown that theoretical calculations agree well with the experimental data [1]. This work was performed with support of RFBR 08-02-00993a.

1. Orlov, N. Yu., Gus'kov, S. Yu., Pikuz, S. A., Rozanov, V. B., Shelkovenko, T. A., Zmitrenko, N. V., Hammer, D. A. /2007/ Laser and Particle Beams 25, pp. 1-9

Experimental Studies of Generation of ~100MeV Au-Ions from the Laser-produced Plasma

TH-0802

L. Laska, K. Jungwirth, J. Krása, E. Krouský, M. Pfeifer, K. Rohlena, J. Skála (Czech IP-AS) D. Margarone, L. Torrisi (INFN Catania, U Messina) J. Ryc (IPPLM Warsaw) J. Ullschmied, A. Velyhan (Czech IPP-AS)

The interaction of intense laser radiation (intensities higher than $\sim 1{\cdot}10^{14}$W/cm^2) with the preformed plasma increases the amount, the charge states and the energy of the produced ions due to various non-linear effects, namely the ponderomotive, relativistic, or magnetic self-focusing (channeling). The plasma, created by the slowly increasing front edge of a long (>100ps) laser pulse, with which the main part of the pulse continues to interact, can be regarded as a kind of preformed plasma. The focus setting (the position of the minimum focus spot with regard to the target surface) determines not only the nominal laser intensity, but also the length (duration) of laser beam interaction with such self-created plasma. Our studies were performed using the PALS iodine high-power laser in Prague with the fundamental ($\lambda = 1.315\mu$m) and the 3rd harmonic ($\lambda = 0.438\mu$m) frequencies, with laser energies of up to ~400J in a pulse <300ps long (intensity up to $5{\cdot}10^{16}$W/cm^2), with the contrast 10^6 at about 2ns prior to the laser pulse maximum, at various angles of target irradiation, and at variable focus positions. Au ions with the kinetic energy of ~100MeV and with charge-states up to 58+ were recorded. Simultaneously, the emission of hard X-rays was investigated and correlated with the generation of fast ions. The reported results should serve mainly to identify the mechanisms participating in the generation and the acceleration of highly charged ions with extremely high kinetic energy. Supported by the Grant Agency of the ASCR, grant IAA 100100715.

Investigations of Acceleration and Collision of Planar Flyer Targets with Massive Target on the PALS Experiment

T. Pisarczyk, A. Kasperczuk, S. Borodziuk (IPPLM Warsaw) M. Kalal (Czech TU) S. Yu. Gus'kov (LPI RAS) J. Ullschmied (Czech IPP-AS) E. Krouský, K. Masek, M. Pfeifer, K. Rohlena, J. Skala (Czech IP-AS) P. Pisarczyk (UT Warsaw)

This paper is summary of investigations regarding acceleration of laser driven thin metal foils or disks using the first (λ_1=1.315μm) and/or third (λ_3 =0.438μm) harmonics of the Prague Asterix Laser System (PALS). A three-frame interferometric system was employed for measuring velocities of the rear side of the foils as well as electron density distributions inside an ablative plasma at different instants of plasma evolution. Volumes of craters produced by collision of accelerated macroparticles with a massive aluminum block were used as an indicator of an efficiency of laser energy transfer into the foil or disk. Our recent investigation was devoted to measurements of the foil velocities with the use of the two opposite positions of the focal point. The focal point of the defocused laser beam (a focal spot radius at the target surface $\sim$300μm) was located either inside (negative position) or in front of the target surface (positive position). It was demonstrated that these two opposite focal point positions give rise to significantly different laser-plasma interactions: with either depression or maximum of the laser intensity distribution in the center of the beam, respectively. It was also verified that the focal point position inside of the target is favorable for plasma jets creation, whereas the opposite case is more effective for acceleration of flyers. In the case of the positive position of the focal point, the flyer velocity is lower by about 25% in comparison to the velocity for opposite position.

TH-09 — Thursday 7th parallel session

TH-0901

LASERIX in 2008: Present Statuts of the French X-ray Laser Facility and Perspectives for Laser Interaction with Matter Investigations, using High Power and Rep-Rate Laser

D. Ros, O. Guilbaud, S. Kazamias, B. Zielbauer, D. Habib, M. Pittman (U Paris Sud)

LASERIX is a high power laser facility intented to realise and use for applications transient collisional X-ray lasers at various wavelengths. In addition new types of XRL schemes giving rise to emission at short wavelengths will be developped using the high energy LASERIX driver. Thus, this laser facility will both offer Soft X-ray lasers in the 30-10nm range and auxiliary IR beam that could be also used to produce XUV sources. This experimental configuration highly enhance the scientific opportunities of the facility. Indeed it will be possible to realise both X-ray laser experiments and more generally pump/probe experiments, mixing IR and XUV sources. Then, this facility will be usefull for the community, opening a large scale of Laser Interaction xith matter investigations. This project is a first step in the exciting and promissing road of the european Extreme Light Infrastructure that could be developed in the next years opening thus a large scale of opportubities for laser interaction matter community

TH-0902

Highly Advanced High Harmonic Coherent Soft X-Ray Laser Sources Towards a Water Window Region Using Laser-Ablated Solid Target Plasma

H. Kuroda, M. Suzuki, M. Baba, R. A. Ganeev, T. Ozaki (ISSP Tokyo)

High-order harmonic generation (HHG) is a very attractive source in the soft X-ray region. Well-established mechanism for HHG is the three-step model of tunnel ionization, acceleration and recombination of electron in a gas medium. An alternative novel nonlinear medium demonstrated is laser-ablated solid target plasma. The advantage of this method is that it allows the use of any material that can be formed into solid target. Furthermore it is capable of generating nonlinear medium with high density. Therefore novel physics phenomena can be expected and it was observed experimentally. We will present the strong resonance enhancement of single harmonic with 1μJ level using strong oscillator strength transition ions [1]. The enhancement of the 13th harmonic at 61nm, the 17th harmonic at 47nm, the 21st harmonic at 37nm, and the 27th harmonic at 29nm has been obtained by using indium, tin, antimony, and tellurium plasmas respectively. These enhancements of single harmonics originated from the laser-induced multiphoton resonance by using strong radiative transition ions. Then, we present the extension of the cutoff energy in HHG by using doubly charged ions [2]. In manganese plasma, the 101st harmonic at 7.9nm generation [3]. Finally, we will present the HHG enhancement from the laser-ablated silver nanoparticles plasma. We expect we can step into water window region by pursuing this novel scheme.

1. R. A. Ganeev, et al., Opt. Lett. 31, 1699 /2006/
2. M. Suzuki, et al., Opt. Express 15, 4114 /2007/
3. R. A. Ganeev, et al., Phys. Rev. A 76, 023831 /2007/

TH-0903

Pumping of a 180eV X-Ray Laser with the PHELIX System

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A simplified pumping scheme [1] was successfully implemented at the PHELIX laser system at GSI Darmstadt to pump a thin layer Samarium target deposited on a glass substrate. A double-pulse structure was prepared in the front-end of PHELIX, amplified in the whole large diameter Nd:Glass chain, and compressed to form two pulses. The use of a single beamline and focussing system for both pulses necessary in the transient collisionally-excited X-ray laser scheme presents a substantial simplification usually connected with beam diameters larger than 20cm. Furthermore, the overlap of both pulses is ensured independently of long-term drifts of beamline components. Total pumping energies between 50 and 100J were equally distributed in two 50ps pulses with a delay of 2 to 4ns and were focused to lines of 100μm and a length of 8mm on the target at an incidence angle of 55 degrees. The output of the X-ray laser is analyzed with a grating spectrometer using a 1200lines/mm flat-field grating and an XUV CCD camera, clearly showing the two Ni-like Samarium emission lines at 6.8nm and 7.3nm. Further experiments are in preparation to optimize this approach which promises a significant reduction of the energy requirements on the way towards water window X-ray laser operation, moving it in reach of 0.1Hz/40J systems like LASERIX [2].

1. D. Zimmer et al., submitted, see also this conference
2. S. Kazamias, K. Cassou, D. Ros, et al., High-repetition-rate XUV laser pumped by Titanium Sapphire laser, towards the LASERIX station, Journal de Phys. IV, 138, 13 /2006/

TH-0904

Extreme Ultra-Violet Emission from Laser Produced Tin Plasmas

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The Ni-like and Co-like EUV radiation emitted from laser produced tin plasmas have been modeled by using the hydrodynamic/atomic physics code EHYBRID. 1.2ns Nd:YAG laser pulses have been used to create plasma. Conversion efficiency of laser energy to EUV radiation has been calculated. The maximum conversion efficiency was obtained 8.75% with 1064nm Nd:YAG laser at power density of $1\cdot10^{13}$W/cm^2 and 20ns pulse duration over $2\cdot\pi$sr. In order to improve conversion efficiency, double-pulse configuration was used. For the maximum conversion efficiency Nd:YAG laser 1.2ps pulse at $6.7\cdot10^{12}$W/cm^2 superimpose on 280ps pre-pulse at $5\cdot10^{12}$W/cm^2. Conversion efficiency of laser energy to EUV radiation has been also investigated as a function of time difference between pulses.

TH-10 — Thursday 8th parallel session

Optical Properties of Aerogel Foil Near Critical Plasma Density Irradiated with Wide-Spectrum Laser

TH-1001

A. N. Starodub, N. G. Borisenko, A. A. Fronya, Yu. A. Merkuliev, M. V. Osipov, V. N. Puzyrev, A. T. Sahakyan, B. L. Vasin, O. F. Yakushev (LPI RAS)

Recent results on interaction of laser radiation with plastic aerogel target, which is a submicron three-dimension polymer network of triacetate cellulose (TAC), are presented and discussed. The KANAL-2 installation (Nd-glass laser, pulse energy up to 300J, output aperture 60mm, pulse duration 2.5ns, average laser intensity on a target up to $5{\cdot}10^{14}$W/cm^2) was used as a source of laser radiation. The laser-target interaction took place at two values of the irradiation linewidth, 2.4nm and 4.2nm. The energy balance measurements have shown that energy transmitted through the target is comparable with that of the incident radiation. Part of it scattered into aperture of a focusing lens does not exceed 1%. Value of energy passed through the TAC target depends on an aerogel density, on its thickness, and may achieve 70% even when the density proves higher than critical. It is found that spectrum of the transmitted radiation is considerably broadened up to 20nm. The second-harmonic generation and other nonlinear effects were experimentally registered under TAC targets irradiation. It is suggested that the TAC target could be used for the laser radiation conversion to optimize the light absorption and to obtain a broad linewidth of incident radiation. As a result, the efficiency of energy yield from active elements may be higher and the laser efficiency increased. The work is partly supported by the Russian Foundation for Basic Research, grants #06-02-17526, #07-02-01148, #07-02-01407.

Investigation of Low-Density Foam Target Plasma Radiation

TH-1002

G. A. Vergunova, E. M. Ivanov, V. B. Rozanov (LPI RAS)

Theoretically [1] it was predicted that it is possible to obtain high yield of X-ray radiation from a plasma of low-density targets doped by high-Z matter. The radiation from a high-density plasma is studied experimentally. In some experiments, high yield of the X-ray radiation was obtained in a specific range of quanta. The intrinsic radiation of plasma of the low-density foam targets is studied. The experiments are taken on up-to-date laser facilities in order to obtain high yield of X-ray radiation and to produce laser thermonuclear fusion. Numerical simulation of experiments is made with the use of 2D hydrodynamic program LATRANT, where the radiation transfer has been taken into account. The laser radiation absorption is calculated in accordance with real geometry.

1. G. A. Vergunova and V. B. Rozanov, Possible efficient conversion of laser radiation into plasma self-radiation, Sov. J. Quantum Electron. 22, 3 /1992/ 239-241

TH-1003

Characteristics of Bremsstrahlung X-ray Sources Created by Picosecond Laser Pulses and Radioprotection Issues for Petawatt Lasers

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Previous experimental and numerical results have shown that in multi-MeV Bremsstrahlung X-ray sources created by picosecond laser pulses, the delivered on-axis dose increases if the laser interacts with under-critical plasmas. The effect of the laser-plasma interaction as a function of the plasma density gradient is thus first studied here, by focusing the short pulse of the Alisélaser on a solid tantalum target coated with plastic. Interaction conditions are modified by irradiating the target front side with a secondary nanosecond heating beam, prior to the main pulse. The length of the expanding plasma is modified by adjusting the delay between the interaction and heating beams. Various diagnostics give access to a whole set of consistent experimental results on the X-ray source properties which are compared successfully to self-consistent numerical simulations obtained with coupled PIC and Monte Carlo codes. All source parameters increase as the plasma length increases, in reason of the increasing number of high-energy electrons near the axis. In a second part of this talk, we use our simulation tools to predict the X-ray and neutron (produced by photonuclear interactions in the target) flash characteristics that can be expected on future PW lasers. Favourable scaling laws for the production of an intense, directional and short duration X-ray source versus intensity are observed. However, these findings also stress that radioprotection will become an important issue for future petawatt lasers operating at the kJ level.

TH-1004

The Interaction of Femtosecond Laser Pulses with a Copper Foil

N. G. Karlykhanov, V. A. Lykov, A. T. Sapozhnikov (RFNC VNIITF) R. Fedosejevs, S. Kirkwood, Y. Y. Tsui (U Alberta)

The results of experiments and theoretical research on interaction of the 150fs laser pulses with a copper foil are presented. The Ti:Sapphire laser intensity on foil surface was in the range of 10^{12}-$3{\cdot}10^{14}$W/cm^2 in experiments carried out at University of Alberta (Canada). The calculations of femtosecond laser pulses interaction with matter and study of the foil blow-off are performed using an 1D ERA code developed in RFNC-VNIITF. The hydrodynamic and electron conductivity with degeneracy effects were taken into account. The wide-range equations of state for solid, gas and plasma were used in ERA-code simulations. The two-temperature case was considered in these calculations by taking into account of energy exchange between electrons and phonons (ions). The laser energy absorption was calculated from Helmholtz equation with complex dielectric permittivity. The scattering of electrons on phonons and free electrons was taken into account in calculation of dielectric permittivity. The results of the ERA-code calculations are in a good agreement with data on laser light reflection that obtained in experiments on interaction of the 150fs laser pulses with copper foils performed earlier at University of Alberta. The presented theoretical work was supported in part by ISTC on the Project #2289.

TH-11 — Thursday 9th parallel session

Nonlinear Force Accelerated Plasma Blocks with Inhomogeneous Rayleigh Density Profile

TH-1101

R. Sadighi-Bonabi (Sharif UT) E. Yazdani (STRI Bonab) Yu Cang, F. Osman (U Western Sydney) H. Hora (U New South Wales)

Following the general solution of electromagnetic waves in inhomogeneous plasmas [1], the nonlinear (pondero motive) force by laser beams is evaluated from hydrodynamics using the genuine two-fluid model and compared with preceding results from the space-charge neutral one-fluid model [2]. This is important for studies of the generation of highly directed plasma blocks [3] of extended thicknesses. The inhomogeneity is adjusted in order to produce the extended effective skin-layer for possible application for a modified fast ignition scheme of laser driven fusion.

1. H. Hora, Plasmas at High Temperature and Density, Springer, Heidelberg /1991/ Section 7
2. H. Hora, Plasmas at High Temperature and Density, Springer, Heidelberg /1991/ Section 10
3. H. Hora, J. Badziak et al Physics of Plasmas 14, 072701 /2007/

Laser-produced Ge Ions Accelerated for Implantation into SiO_2 Semiconductor

TH-1102

M. Rosinski, B. Badziak, P. Parys, J. Wolowski (IPPLM Warsaw) M. Pisarek (Warsaw UT)

Application of electrostatic fields for acceleration and formation of laser-generated ion beams enables to control the ion stream parameters in broad energy and current density ranges. A beam of accelerated laser-produced ions is attractive for direct ion implantation in thin layer of semiconductor material for modification of electrical and optical properties of semiconductor devices. It also permits to remove the useless laser-produced ions from the ion beam designed for implantation. For acceleration of ions produced with the use of a low fluence repetitive laser system (Nd:glass: 2Hz, pulse duration: 3.5ns, pulse energy: ~0.5J, power density: 10^{10}W/cm^2) in IPPLM the special electrostatic system has been prepared. The laser-produced ions passing through the diaphragm have been accelerated in the system of electrodes. The accelerating voltage up to 40kV, the distance of the diaphragm from the target, the diaphragm diameter and the gap width were changed for choosing the desired parameters of the ion stream. The characteristics of laser-produced Ge ion streams were determined with the use of precise ion diagnostic methods, namely: electrostatic ion energy analyser and various ion collectors. The laser-produced and post-accelerated Ge ions have been used for implantation into SiO_2 for modification of semiconductor properties. The characteristics of implanted samples were measured using Auger electron spectrometry.

Resonant Plasma Wave Excitation in Guided Laser Wakefield

TH-1103

K. Cassou, F. Wojda, B. Cros (LPGP) G. Genoud, M. Burza, O. Lundh, A. Persson, G. G. Wahlström (Lund U) N. E. Andreev (JIHT RAS)

The laser wakefield accelerator (LWFA) is currently the most promising approach to high performance compact electron accelerator. In the linear regime or moderately nonlinear regime of LWFA, accelerating electric fields are of the order 1-10GV/m and relativistic electrons injected into the wave can acquire an energy of the order of one GeV over a length of a few centimeters. The control of the characteristics of the accelerating plasma wave is crucial for achieving a usable laser-plasma accelerator stage. The present limitation for the energy of accelerated electrons in the standard LWFA is due to the small acceleration distance, limited to a few Rayleigh lengths, typically of the order of one millimeter. The extended propagation of a laser pulse over many Rayleigh lengths can be achieved by the use of waveguides, such as plasma channels and hollow-core capillary waveguide (HCW). The main objective of our current work is to demonstrate experimentally the excitation, in the linear regime, of a plasma wave in the wake of an intense laser beam guided in a HCW over several centimeters. An experiment has been performed using the TeraWatt Ti:Sa laser at the Lund Laser Center. HCW lengths up to 8cm have been used to guide the laser beam with high coupling efficiency. The spectrum of the short laser pulse was measured at the output of the HCW. Large redshifts of the fundamental laser spectrum have been observed. Comparison with numerical modeling confirm the production of a high accelerating field.

Stochastic Heating in High Intensity Laser-Plasma Interaction. Application to the Wake Field Acceleration Process

A. Bourdier (CEA-DAM)

Recently, PIC simulations results published by Tajima et al. and Sheng et al. have shown that chaos can play an important role in the efficient electron heating observed in laser-plasma interaction at very high intensities. These results led us to investigate the condition under which significant stochastic heating is likely to take place. First, we shall consider the dynamics of a single charged particle in the field of a high intensity wave propagating in an unmagnetized vacuum or plasma. In a second part, the effect of a constant homogeneous magnetic field will be discussed. Third, in the case of a plasma interacting with several electromagnetic waves, the use of Chirikov's criterion to predict the conditions favouring stochastic heating will be presented. Finally, it will be shown that when considering a low density plasma interacting with a high intensity wave perturbed by a low intensity counterpropagating wave, stochastic heating can provide electrons with the right momentum for trapping in the wake field and efficient acceleration.

1. Physica D, Vol. 206 /2005/
2. Laser and Particle Beams, Vol. 25 /2007/

FR-01 — Friday plenary session

Diagnostics of Warm Dense Matter using Thomson Scattering

FR-0101

C. Fortmann, T. Bornath, A. Przystawik, R. Redmer, H. Reinholz, G. Röpke, R. Thiele, J. Tiggesbäumker (U Rostock) L. Cao, E. Förster, I. Uschmann, U. Zastrau (FS-U Jena) T. Döppner, S. H. Glenzer (LLNL) S. Düsterer, R. R. Fäustlin, T. Laarmann, P. Radcliffe, S. Toleikis, T. Tschentscher (HASYLAB DESY) G. Gregori (Clarendon Lab.) H. J. Lee (UC Santa Barbara)

Thomson scattering provides a unique tool for plasma diagnostics. The scattering spectrum gives direct access to plasma properties like density, temperature and composition. With the advent of intense, coherent light sources in the VUV and soft X-Ray regime the applicability is extended to high energy density plasmas and warm dense matter. In such systems, collisions among constituents are of primary importance for the prediction and interpretation of the scattering signal. We present a systematic approach to the dynamical structure factor using the Born-Mermin Ansatz to include collisions via the dynamical collision frequency. Results are compared torecent experimental data, carried out on solid density targets. Results from a first scattering experiment on solid density hydrogen at the free electron laser facility FLASH at Hamburg will also be presented.

Wave Packet Simulations for the Insulator-Metal Transition in Dense Hydrogen

FR-0102

G. Zwicknagel, B. Jakob, P.-G. Reinhard, G. Toepffer (U Erlangen)

Although hydrogen is the simplest of all elements its behavior at extreme density and pressure poses a fundamental challenge to experiment and theory, in particular in view of the question about a transition from molecular hydrogen to a metal or metallic fluid. Here, dense hydrogen is studied in the framework of wave packet simulations. In this semi-quantal many-body simulation method the electrons are represented by suitably parameterized, antisymmetrised Gaussian wave packets. The equilibrium properties and time evolution of the system are obtained with the help of a variational principle and a pseudo-hamiltonian dynamics of the time-dependent parameters of the wave packets. The antisymmetrisation is completely incorporated by numerically robust matrix inversions. Effects of the applied periodic boundary conditions as well as of the non symplectic structure of the equations of motion have been taken into account. At room temperature the results for the isotherm are in good agreement with anvil experiments. At higher densities, beyond the range of the experimental data, the electrical conductivity and the pair-distribution function indicate a transition from a molecular to a metallic state. The wave packets become delocalized and the electrical conductivity increases sharply. The phase diagram is calculated in a wide range of the pressure–density–temperature space. The observed transition from the molecular to a metallic state is accompanied by an increase in density in agreement with recent reverberating shock wave experiments.

Proton Tomography: Tomographic Reconstruction of a High Contrast Laser Driven Proton Source

FR-0103

S. Ter-Avetisyan (QU Belfast) M. Schnürer, P. V. Nickles, W. Sandner (MBI Berlin) T. Nakamura (KPSI JAEA) K. Mima (ILE Osaka)

Sectional images of a laser produced proton source were obtained in an energy dispersive mode by using a specifically modified Thomson spectrometer. The tomographic reconstruction of the proton source demonstrates its complexity. The laser driven ion source is a highly organized dynamic system. The proton emission is laminar and obeys to continuous distributions in space and time. It relies on a well defined interrelation between spatial and momentum distributions of emitted ions. A source point which emits protons with an energy E_1 becomes a source for protons with an energy E_2, where $E_2<E_1$, and the emission angles are correlated by $Q(E_2)<Q(E_1)$. Therefore any point located within the proton beam cone can be reached by protons emitted from a certain target-source area. Consequently the proton spectrum in that point can be controlled by controlling the proton source area. In case of a flat target and a perfectly round laser focal spot the proton source is circular symmetric and each source point behaves similarly: as higher the proton energy as smaller the source size and as bigger the size related emission angle. Only the symmetry axis is unique; here all protons are emitted at 0 degree to the target normal. The results are significant for understanding the properties of the accelerated beam and the optimization of the ion source. The latter are essential for a number of applications where the particular beam characteristics are important.

FR-0104

Absorption and Ionization in Clusters Irradiated by Intense Laser Pulses

T. Bornath (U Rostock) P. Hilse, M. Schlanges (U Greifswald)

The interaction of intense laser fields with rare gas and metal clusters is investigated using the nanoplasma model which allows to describe different processes like ionization, heating, and expansion by a coupled set of hydrodynamic and rate equations. Motivated by recent experiments, special attention is directed on the ionization dynamics [1]. In the high-density nanoplasma, the influence of correlation effects such as the lowering of the ionization energy is important for the ionization kinetics. Using generalized electron impact ionization rates, we found a significant enhancement of the yield of highly charged ions [1]. Calculations for dual pulse excitation show a maximum yield for a certain delay between the pulses which confirms the results of experimental investigations [2]. A modern tool in laser experiments is pulse shaping which allows to affect specifically the dynamics of the system. In particular, the yield of highly charged ions can be controlled [3]. For an understanding of the underlying physical processes in the dynamics of laser-cluster interaction, a theoretical description using a genetic algorithm and basing on the relatively simple nanoplasma model seems to be promising. Our first calculations show a considerable enhancement of the ion yield produced by the optimized laser pulse. The work was supported by the Deutsche Forschungsgemeinschaft, SFB 652.

1. Th. Bornath, P. Hilse, M. Schlanges, Laser Physics 17 /2007/ 591
2. Th. Döppner et al., Phys. Rev. 73 /2006/ 031202
3. N. X. Truong et al., private communication

FR-0105

Calculation of Spectral Opacities of Near-LTE Al Plasmas

P. A. Loboda, S. V. Koltchugin, V. V. Popova (RFNC VNIITF)
A. V. Bessarab, N. A. Suslov, N. V. Zhidkov (RFNC VNIIEF)

Using the SPECTR-DTA numerical model based on detailed description of bound-bound and bound-free photoabsorption to calculate spectral opacities of LTE plasmas, the modeling of K-shell photoabsorption spectra of near-LTE Al plasmas was performed at the densities ρ= 0.02-0.2g/cc and temperatures T=10-80eV. Calculated X-ray transmission spectra are compared to the data of special-purpose experiments with thin aluminum foils backlighted by quasi-continuum radiation of point X-ray sources conducted on the Iskra-5 laser facility.

FR-02 — Friday 1st parallel session

On the Feasibility of New Laser Fusion by Intense Laser Field

FR-0201

K. Imasaki, D. Li (ILE Osaka)

We have proposed a feasibility of new approach of laser induced nuclear reaction using intense laser field [1]. This is a non-Gamov nuclear reaction model. More than EW laser was required to distort the coulomb barrier to obtain enough penetrability for tunneling in previous model. In this presentation, improvements for the model and application for D-D reaction are discussed. Reference:

1. Imasaki and Li, Laser and Particle Beams 26, /2008/ p3

Studies on Possible Alternative Schemes Based on Two-Laser Driver for Inertial Fusion Energy Application

FR-0202

C. Strangio (ENEA) A. Caruso (KORE U)

In the present scenario lasers featured by entirely flexible nanosecond pulse-shaping will be used for demonstrative experiments (NIF and LMJ) to validate already improved central-ignition IFE relevant schemes. Meanwhile, along a similar path of challenging research, the HiPER project is arising as reference installation for demonstrative experiments on the Fast Ignition (FI) approach that requires two lasers pulses with different duration (ns, ps) and specialized role (compression, ignition). In this context pulse durations, between few ps up to hundreds of ps, wider than those now featuring the short pulse FI class drivers, in perspective could represent an important tool to test an extended class of IFE relevant approaches. Recent results on a new scheme based on two-laser driver will be presented after a short review of others having similar driver requirements previously studied in the framework of IFE Keep In Touch activity at Frascati EURATOM-ENEA Association.

Ablation and Spallation of Solid Films Exposed to Femtosecond Laser Pulses

FR-0203

S. Anisimov, N. A. Inogamov, Yu. V. Petrov (LITP RAS)

Motion of Lennard-Jones solids and metals near the ablation threshold is investigated by molecular dynamics simulation. Universality of the ablation threshold fluence with respect to cohesive energy of solid irradiated by the femtosecond laser pulse is demonstrated for Lennard-Jones solid and metals simulated by many-body EAM potentials.

Fast Ignition by the Detonation Wave from the Impactor Laser-accelerated up to Velocity of 300-500km/s

FR-0204

S. Yu. Gus'kov (LPI RAS) M. Murakami (ILE Osaka)

New approach to fast ignition by accelerated projectile impact is proposed. The approach consists in the fast ignition by the detonation thermonuclear wave, which is initially initiated in the impactor itself and then propagates to a pre-compressed thermonuclear fuel of ICF target. The structure of detonating impactor provides the quasi-adiabatic compression of igniter layer after its shock wave braking. There are two advantages of such an approach. First of them is the removal of a problem to transfer a impactor's kinetic energy to a dense fuel assembly of ICF target. Another one is that the quasi-adiabatic compression of DT-igniter gives a possibility to provide an ignition of ICF target at the impactor's velocities of 300-500km/s that is significantly less than the velocities of 1-2·10^3km/s which are foreseen in other impact fast ignition proposals. Several types of detonating impactor are proposed. One of them represents a multi-layer impactor consisted of DT-ice igniter, pusher made from heavy-element material and ablator made from light-element material. These three layers could be separated by the gaps containing a moderate density matter to minimize the negative influence of hydrodynamic instability. The theory of impact-driven detonation by multi-layer projectile which takes into account a compressibility of a dense DT-fuel of ICF target and effects of edge initiation is developed. The work is supported by RFFI Grant #06-02-91226-JF.

FR-03 — Friday 2nd parallel session

Efficiency of Second Harmonic Generation in the Nd-Glass LASER under a Large Number of Transverse Modes

FR-0301

A. T. Sahakyan, A. N. Starodub, M. V. Osipov, V. N. Puzyrev, B. L. Vasin (LPI RAS)

In order to improve the efficiency of a multimode Nd-glass laser at the wavelength of 0.53μm, the authors studied the dependence between the efficiency of conversion of KANAL-2 laser broadband radiation into the second harmonic of a KDP crystal 60x60x30mm^3 (OOE type of synchronism) and the number of transverse modes n$\sim$10^2-10^3 within the power density range I$\sim$0.2-2.5GW/cm^2, and the radiation divergence being 2$\alpha\sim$0.47-3.5mrad. The investigations were performed for both the linearly polarized and depolarized radiation, since the polarized radiation assumes an introduction into the laser optical system of the polarizers, which reduce the output energy, and, hence, the laser efficiency as well. It was found that if one changes n from 10^3 to 10^2, and 2α=3.5mrad is changed to 1.17 mrad, then the conversion efficiency grows from K$\sim$20% up to K$\sim$40%. No important difference in the conversion efficiency of a polarized and depolarized radiation was observed. The maximum conversion efficiency came up to $\sim$50% at n$\sim$10^2 and 2α=0.47mrad. The work is partly supported by the Russian Foundation for Basic Research, grant N 07-02-01407.

Extreme Ultraviolet Emission from Dense Plasmas Generated with Sub-10fs Laser Pulses

FR-0302

J. Osterholz, F. Brandl, M. Cerchez, T. Fischer, D. Hemmers, B. Hidding, A. Pipahl, G. Pretzler, O. Willi (U Düsseldorf) S. J. Rose (IC London)

The extreme ultraviolet (XUV) emission from dense plasmas generated with sub-10fs laser pulses with varying peak intensities up to 3·10^{16}W/cm^2 is investigated for different target materials. K shell spectra are obtained from low Z targets (carbon and boron nitride). In the spectra a series limit for the hydrogen and helium like resonance lines is observed indicating that the plasma is at high density and pressure ionization has removed the higher levels. In addition, L shell spectra from titanium targets were obtained. The spectra are analyzed with computer simulations including the hydrodynamic expansion of the plasma and collisional radiative calculations of the XUV emission. Basic features of the measured K and L shell spectra are reproduced in the simulations.

Analysis of the energy transfer in low-density structured foam-like targets in the experiments on the LIL facility

FR-0303

D. Barishpoltsev, V. Rozanov, S. Yu. Gus'kov, N. Demchenko, E. Ivanov (LPI RAS) E. Aristova (IMM RAS) S. Depierreux (CEA-DIF) C. Labaune (LULI) C. Tikhonchuk (CELIA)

Experiments on irradiation of targets made of a low-density structured material were performed on the LIL facility. The laser pulse parameters were as follows: energy 10kJ, duration 3ns, intensity 4·10^{14}W/cm^2, wavelength 0.351μm. This paper presents a theoretical analysis and results of numerical modeling of the energy transfer in the target obtained in one- (RAPID) and two-dimensional (LATRANT) numerical calculations. The calculation procedure had been developed earlier for the analysis of analogous experiments performed on the PALS facility [1]. However, in the present experiments the laser parameters are different: the pulse duration is 4 times longer and the energy delivered is more than 100 times greater. The numerical modeling successfully reproduces the major experimental results: the energy balance, the evolution of plasma temperature and density. The velocity of the thermal front was calculated with a post-processor that describes the X-ray radiation emission and propagation to the detector. The work was partially supported by the RFFI Grants 08-02-91202 and 08-01-00291. The experimental work was coordinated under the auspice of the Institute Lasers and Plasmas. The authors acknowledge the support of the operation team of the LIL facility who made these experiments possible.

1. V. Rozanov et al. Energy transfer in low-density porous targets doped by heavy elements, IFSA 2007, paper TuPo26, Book of Abstracts, p.173.

PO — Poster session

Test Stand for Laser-accelerated Ions for Future Synchrotron Injection

PO01

I. Alber, K. Harres, F. Nürnberg, M. Schollmeier, M. Günther, M. Roth (TU Darmstadt) A. Blažević, T. Stöhlker (GSI)

The application of laser-accelerated ions as a next generation ion source requires transport control and reduction of the energy spread to a monoenergetic beam. Focusing of laser-accelerated protons using two miniature magnetic quadrupoles is demonstrated. Further investigations are prepared to collimate laser-accelerated protons with a pulsed solenoid. In addition it is planned to construct a debunching unit in order to compress the beam's energy spectrum. First simulation results of the ion beam collimation and transport are presented.

Updated Threshold for Laser Driven Block Ignition of Neutron Lean Fusion Energy

PO02

N. Azizi, B. Malekynia, M. Ghoranneviss (Islamic Azad U) H. Hora (U New South Wales) G. H. Miley (U Illinois) X. He (IAPCM Beijing)

Neutron lean fusion reactions as proton-boron(11) or helium(3)-helium(3) are usually requiring extremely high laser energy and compression for laser driven inertial confinement fusion. A new aspect was introduced from anomalous interaction of ps laser pulses of TW to PW power due to suppression of relativistic self focusing if prepulses are cut off by a contrast ratio higher than 10^8 resulting in space charge neutral plasma blocks having ion current densities above 10^{11}A/cm^2 [1]. The difficulty for the incident blocks to ignite solid state density DT fuel is the need of a very high energy flux density E* as threshold of $4{\cdot}10^8$J/cm^2 derived by the theory of Chu (1972). A reduction of this threshold was derived if the later discovered inhibition factor for thermal conduction because of double layer effects [2], and if the shorter stopping lengths of the alphas from the reaction due to collective effects are included. These conditions were studied for neutron lean reactions resulting in considerably higher threshold temperatures but not very much higher E* values.

1. H. Hora, J. Badziak et al. Phys. Plasmas 14, 072701 /2007/
2. M. Ghorannviss, B. Malekynia, H. Hora, G. H. Miley and X. He, Laser and Particle Beams 26, 105 /2008/

Simulation of the Hohlraum for a Laser Facility of Megajoule Scale

PO03

M. N. Chizhkov, A. V. Vronskiy, M. Yu. Kozmanov, S. N. Lebedev, V. A. Lykov, V. V. Rykovanova, V. N. Seleznev, K. I. Selezneva, O. V. Styakhnina, A. A. Shestakov (RFNC VNIITF)

The Sinara code [1] is developed in VNIITF which allows solving the equations of two dimensional gas dynamics together with the equations of radiation transport in spectral-kinetic approximation by the DSn-method [2]. The three-dimensional model of laser light absorption in geometrical optics approximation is included in this code. Results of calculations of the laser hohlraum intended for achievement of indirectly-driven thermonuclear ignition are presented in the report. For laser energy saving and improving of X-ray flux uniformity on the target the configuration of hohlraum in the form of a rugby ball [3] has been used.

1. A. D. Gadzhiev, V. V. Gadzhieva, S. Yu. Kuzmin et al. VANT, Math. Mod. Phys. Proc. Series, 3, pp. 25-35 /2000/ in Russian
2. A. D. Gadzhiev, V. N. Selezhyov, A. A. Shestakov et al. VANT, Math. Mod. Phys. Proc. Series, 4, pp. 33-46 /2003/ in Russian
3. P. Amendt, C. Cerjan, A. Hamza et al. Phys. Plasmas 14, 056312 /2007/

PO04

Nuclear Excitations in High-Parameter Plasmas and Other Challenging Problems

L. Drska, R. Liska, M. Sinor, P. Vachal (Czech TU)

There has been a great interest in the processes of nuclear excitation in high-parameter laser-produced plasma in recent years. A series of papers devoted to the theory of this event have been published. Several experiments have already been attempted to observe the excitation of the lowest nuclear levels of medium/high Z nuclides (^{181}Ta, ^{235}U), all the same ambiguous or unsuccessful. In the first part of this paper the situation will be overviewed, using experiences earned in computational and experimental studies of tantalum plasma created by a medium-power laser facility (PALS). Some results of preliminary simulations using an 1D hydrodynamic code will be shown. The second part of the contribution will be devoted to the analysis of potential future attempts to uneasy/tricky experiments in this area, using both high-intensity and high-energy laser systems to be available in the near future. A special attention will be paid to 2D simulation of sophisticated targets for this experiments, some illustrative results will be shown. In the last part of the talk the problem of nuclear excitation will be considered as a part of general topic of nucleoreactive plasma, some related challenging problems in laboratory nuclear astrophysics (low sigma measurements, reaction yield modification) and potential approaches to their studies will be indicated.

PO05

Influence of Visible Light of Laser Irradiation on the Surface Morphology and Optical Properties of Polycarbonate Films

H. Ehsani Amri (Islamic Azad U, Nour Azad U) S. Saghfi, M. Ghoranneviss (Islamic Azad U)

In this paper, we have investigated the effects of flat-top distribution laser beams on optical parameters of polycarbonate (PC) thin films. The second harmonics of Nd:YAG laser (532nm) and He:Ne laser (632nm) have been employed as optical coherent sources. Transmission has been considered as a key optical parameter. It has been seen that the transmission factor of PC films would be decreased by 15% after illuminating by He:Ne laser. The decrease of this factor for 532nm beam was 25%. The morphological changes of the surface after illumination by these beams have been obtained by atomic force microscopy (AFM). Furthermore, the surface roughness caused by He:Ne and Nd:YAG lasers are strongly depend on the incident photon energy. The PC film illuminated by 532 nm beams deviates the beam path 10^3 times more compared with sample illuminated by 632nm for the same amount of energy density.

PO06

Charge States of O-Ions in Hydrogen

B. Erler (TU Darmstadt) K. Katagiri, S. Nishinomiya, H. Ikagawa, T. Watahiki, J. Hasegawa, Y. Oguri (Tokyo IT)

An electrostatic charge spectrometer using a position sensitive semiconductor detector for measurement of single O-ions in the energy range of 3-7.5 MeV has been designed. The spectrometer was tested in an experiment with hydrogen gas ($1.48{\cdot}10^{24}$m^{-3}). The charge state measured during this experiment was signifficantly higher than the values predicted by semiempirical formulas (Betz and Schiewitz) and Monte Carlo simulations (charge exchange cross sections from binary encounter model and formula by Schlachter).

Energy Loss of Heavy Ions in Laser-produced Plasmas

PO07

A. Frank, M. Günther, K. Harres, D. H.H. Hoffmann, R. Knobloch-Maas, F. Nürnberg, A. Otten, M. Roth, A. Pelka, G. Schaumann, A. Schökel, M. Schollmeier, D. Schumacher, J. Schütrumpf (TU Darmstadt) A. Blažević, T. Heßling (GSI) H. G. Bohlen, W. von Oertzen (HMI Berlin)

At GSI the interaction of heavy ions with laser-produced plasmas is investigated. The nhelix laser system allows the creation of carbon plasmas with temperatures greater than 100eV and electron densities of up to 10^{23}cm^{-3} which is probed by the UNILAC accelerator. This poster presents experimental results from these experiments. Furthermore the first energy loss experiments with the Phelix laser system have been conducted. In addition the energy loss was theoretically calculated with a scaled extended Bethe formula. A Monte Carlo code was developed to calculate the projectile charge state in a carbon plasma.

Numerical Studies of the Ion Stopping in Porous Targets for nhelix-Laser, UNILAC Crossing Experiments

PO08

A. Gnutov, V. Vatulin, K. Volkova, P. Kuznetsov, L. Morenko (RFNC VNIIEF)

The experiments for the study of ion beam interaction with plasma are performed on the nhelix and the UNILAC facility. One of the study directions is the experiments with plasma, generated at the irradiation of low-density CH targets. This paper presents the results of the numerical simulation of 144MeV Ar ions interaction with plasma generated under the 50J and ∼10ns laser pulse impact. The calculations were performed with the 2D set-up using a Monte Carlo code simulating laser, X-ray and ion radiation.

Relativistic Laser Intensity Measurement by Nuclear-Activation based Diagnostics

PO09

M. Günther, M. Roth (TU Darmstadt) A. Blažević (GSI)

Recent progress in ultra-intense lasers induces focused intensities ($I>10^{19}$W/cm^2) in the highly relativistic regime. At such high intensities, an intense relativistic electron current is injected from the plasma created on the laser focal spot inside the target. The laser absorption and the laser peak intensity during the laser-solid interaction are still unknown. The measurement of the laser peak intensity within the relativistic range with conventional techniques is not directly possible, mainly because the laser intensity is determined by the laser-plasma interaction itself. A first question is how large is the actual laser peak intensity during the laser-solid interaction. The knowledge of the peak intensity is important for the investigation of the relativistic laser plasma regime and the resulting applications. One of the currently investigated applications is the laser assisted ion acceleration. The second important question is the transport of relativistic electrons through dense matter, which highly relevant for the feasibility of the fast ignition concept. The used diagnostic is a nuclear activation-based method to study the highly relativistic electron dynamics in laser-solid interaction. In order to determine the 'temperature' of the hot electron distribution by nuclear pyrometry we use activation targets as a kind of calorimeter consisting of a composition of several isotopes with different photon-neutron reaction cross sections in the preferred (g,n) reaction type. The consequence is a relatively high reaction yield for a wide range of photon energies. The determination of the relativistic electron distribution in a wide range of laser intensities and thus the laser peak intensity will be possible. In this presentation the current research is shown.

PO10

Modification of Spot Size Oscillations of an Ultra-intense Laser Beam in Plasma with a Density Ramp

M. Habibi, M. Ghorbanalilu (TM Azarbaijan U) R. Sadighi-Bonabi, E. Yazdani (Sharif UT)

It is known that relativistic self focusing phenomena in the laser plasma interaction decreases the spot size of the laser beam. Beyond the focus,the nonlinear refraction effect dominates and causes to the laser beam defocuses. Thus the spot size of the laser increases and oscillates, periodically. In comparison to the previous works [1,2] not only the spot size oscillations are decreased, but the number of oscillations and self focusing are reduced. In this work we showed the spot size oscillations of laser beam decreases with plasma density ramp. The numerical calculations are presented.

1. V. K. Tripathi, et al, Plasma channel charging by an intense short pulse laser and ion coulomb explosion, Physics of Plasmas 12, 043106 /2005/
2. D. Gupta, et al, Plasma density ramp for relativistic self focusing of an intense laser, J. Opt. Soc. Am. B 24, 5 /2007/

PO11

Characterization of Laser Heated Hohlraum Targets

T. Heßling (GSI)

Hohlraum targets are suitable as radiation converters to transfer energy from coherent monochromatic laser light into incoherent thermal radiation. The plasmaphysics group from the TUD and GSI is investigating these type of targets. The thermal radiation is used to heat a secondary target volumentric and homogeneously. A beam of heavy ions is sent through the resulting plasma and its energy loss will be determined. Recent experimental results as well as a general overview of the topic will be presented here.

PO12

Interaction of Intense Laser Beams with Dielectric Matter

H. Krutsch, D. H.H. Hoffmann (TU Darmstadt) B. Rethfeld (TU Kaiserslautern)

Transparent dielectrics irradiated with intense laser beams become opaque and absorbing when certain thresholds are exceeded. This behavior, known as dielectric breakdown, is caused by increasing free electron density. We calculate the interaction of a laser pulse with a dielectric, considering free electron density and dielectric material parameters. We solve a system of Boltzmann equations where each considered process is included by its corresponding complete collision integral. As the free electron density approaches the critical plasma density, the electric field inside the dielectric increases and the dielectric becomes absorbing and opaque. Also, the ion density increases with increasing free electron density, and (light) absorption by inverse bremsstrahlung becomes important. Thus, we track the changing dielectric function depending on free electron density, and identify the physical mechanisms leading eventually to dielectric breakdown.

PO13

Numerical Study of Plasma Parameters Achieved due to the Impact of the First-Harmonic Laser Beam Generated by the Phelix Facility on Planar Targets

P. Kuznetsov, K. Volkova, G. Eliseev, L. Morenko, A. Tikhonov (RFNC VNIIEF)

In the interests of performing experiments on the Phelix laser facility the numerical study of the Nd-laser first harmonic impact (1.053μm) on planar carbon foils was performed. The goal of the work is to determine the parameters of the generated plasma and the amounts of reflected laser energy. Carbon foils, 0.5μm and 1μm thick, are considered. The laser pulse with the duration of 1ns (FWHM) impacts on the target. The calculations were performed with the 2D set-up using a Monte Carlo code simulating laser and X-ray radiation. The gas-dynamic motion of the two-temperature environment, laser beam reflection from the surface of the critical density, the electron thermal conductivity with classical coefficient were taken into account.

Contactless Conductivity Measurements for HEDP Experiments with Heavy Ion Beams

PO14

J. Ling, S. Udrea, D. H.H. Hoffmann, J. Menzel, N. Müller (TU Darmstadt) A. Fertman, B. Yu. Sharkov, V. Turtikov (ITEP) A. Hug (GSI, TU Darmstadt) M. Kulish, V. Mintsev, D. Nikolaev, N. Shilkin, V. Ternovoi (IPCP RAS) D. Varentsov (GSI)

The high intensity heavy ion beams provided by the accelerator facilities of the Gesellschaft für Schwerionenforschung (GSI) are an excellent tool to produce large volumes of high energy density (HED) matter. During the last few years development of new diagnostic techniques allowed for a series of measurements of the electrical resistivity of heavy ion beam generated HED matter. All of this techniques have been based on contact methods. In this report we present the first steps for the development of a contactless method, using high frequency reflection techniques. Such techniques are well known and used at relatively low frequencies. The main goal of the present work is to adapt them to the experimental conditions at HHT area of plasma physics group. This involves both development of appropriate targets and a measurement setup which should work at frequencies up to a few GHz.

Simulation-based Analysis of Interferometry Data on Laser-heated Plasmas

PO15

D. Löb, M. Roth (TU Darmstadt)

During carbon foil ablation experiments at the nhelix laser system of GSI, a transversal laser beam is deployed for Wollaston interferometry. Bayesian methods are used to benchmark individual radiation-hydrodynamic simulations and entire codes (MULTI, HELIOS) based on the resulting interferometry data.

Atomic Database SPECTR-W3 for Plasma Spectroscopy and other Applications. Current Status and Perspectives

PO16

P. A. Loboda, N. N. Bakshayev, S. V. Gagarin, S. A. Markelenkov, S. V. Morozov, V. V. Popova (RFNC VNIITF) A. Ya. Faenov, A. I. Magunov, T. A. Pikuz, I. Yu. Skobelev (JIHT RAS) A. M. Urnov, L. A. Vainshtein (LPI RAS)

The SPECTR-W3 information-reference system was developed in 2001-2003 and realized as an online Web resource based on the factual atomic database SPECTR-W3 (http://spectr-w3.snz.ru). The information accumulated in the SPECTR-W3 database contains about 450,000 records and includes the experimental and theoretical data on ionization potentials, energy levels, wavelengths, radiation transition probabilities, and oscillator strengths, and the parameters of analytical approximations of electron-collisional cross-sections and rates for atoms and ions. To date, the SPECTR-W3 ADB is still the largest factual database in the world, containing the information on spectral properties of multicharged ions. In 2007 this collaborative effort was followed by the new project aimed at the creation of a qualitatively updated version of the SPECTR-W3 atomic-data information-reference resource on the web to provide free access to an essentially extended SPECTR-W3 atomic database and the facilities for direct submission of new author's atomic data for the follow-on dissemination through the SPECTR-W3 resource. A new version of SPECTR-CD, fully functional local analog of

SPECTR-W3, will also be generated for the off-line use and will be available for downloading from the SPECTR-W3 website. The results of the project are intended for public and non-profit use. The work has been supported by the International Science and Technology Center under the project #3504.

PO17

Production of Embedded Metallic Microdots for Study of Fast Electron Collimation in High Power Laser Experiments

H. Lowe (RAL)

Targets consisting of a central metallic microdot embedded in a plastic disc were requested and delivered to a TAP experiment initially in August 2007 and then again in January 2008 to study the magnetic collimation of fast electrons. A method is under development to produce similar targets consisting of an iron microdot embedded in an aluminium disc for further studies of fast electron collimation.

PO18

Collective Alpha Particle Stopping for Reduction of the Threshold for Laser Fusion using Nonlinear Force Driven Plasma Blocks

B. Malekynia, M. Ghoranneviss (Islamic Azad U) H. Hora (U New South Wales) G. H. Miley (U Illinois)

The anomaly of laser plasma interaction with laser pulses of TW to more than PW power and ps duration led to a very unique generation of space charge neutral plasma blocks by a skin layer interaction avoiding the relativistic self-focusing. This is in contrast to the numerous usual experiments. The plasma blocks have ion current densities above 10^{11}W/cm^2 and may be used for a fast ignition scheme with comparably low compression of the deuterium tritium DT fuel. The difficulty is that a very high energy flux density E* of the ions is necessary according to the Bobin-Chu hydrodynamic theory of 1972. This theory did not include the later discovered collective effect for the stopping power of the alpha particles nor the problems with the inhibition factor for reducing the thermal conductivity due to electric double layers. The action of the double layers was studied before [1] and we present now the results how the collective effect causes in a reduction of the threshold value of E*. We arrive at a reduction for ignition by a factor of about fife.

1. M. Ghoranneviss, B. Malekynia, H. Hora, G. H. Miley and X. He, Laser and Particle Beams 26 /2008/ electronic publication 10.10^{17}/S026303460800013X

PO19

On the Interaction of Particle Beams and Matter in Space, Relativistic Theory

C. V. Meister (SPP Potsdam)

This contribution deals with the analysis of particle beams and their interaction with matter in astrophysical, especially binary star systems. The possibility of the excitation of beam instabilities in relativistic systems is investigated. The corresponding quasi-linear plasma theory is further developed and applied. An estimate of the saturation energy of waves in binary star systems is performed.

First Laser Plasma Experiments with Cryogenic Targets at Z6-GSI

PO20

J. Menzel, D. H.H. Hoffmann, M. Imran, A. Pelka, M. Roth, D. Schumacher, S. Udrea (TU Darmstadt) A. Blažević, T. Heßling, K. Weyrich (GSI) D. O. Gericke, A. Grinenko (U Warwick)

Intense heavy ion beams delivered by the accelerator facilities of the Gesellschaft für Schwerionenforschung (GSI) mbH Darmstadt facilitate together with the two laser systems NHELIX and PHELIX pioneering beam-plasma beam-plasma interaction experiments. The ultimate goal of the work presented here is the employment of cryogenic solid-state Deuterium and Hydrogen targets in experimets for the measurement of the energy loss of heavy ions in dense, laser produced plasmas. The first results of test experiments with nitrogen are discussed within this contribution.

Plasma Modeling and Finiteness of Instrumental Resolution Scales

PO21

N. Minkova (Tomsk SU)

The classical statistical approach to plasma modeling operates with one-particle probability functions what originates from the assumption that the particles' coordinates are distinguishable. Finite instrumental resolution scales that exceed interparticle lengths is considered in the present paper in the frame of the statistical approach based on Liouville theorem. The latter is modified for open systems. The produced model describe plasma by multiparticle probability functions in terms of fluctuations. This model is compared to one- and two-particle kinetic models. Its application to solar wind plasma expansion yields macroscopic parameters that are consistent with observational data.

Quasi Mono-energetic keV X-ray Beam Produced by Ultra-intense Laser-produced Electrons

PO22

M. Mohammadi (Khaje Nasir U) R. Sadighi-Bonabi (Sharif UT)

Quasi mono-energetic X-ray beams generated from thin targets by interaction of mono-energetic electron beams from 600mJ, 80fs laser pulse. A micron-scale laser-produced plasma creates, accelerates relativistic mono-energetic electron bunches. As such electrons propagate in the ion channel produced in the wake of the laser pulse, the accelerated electrons can interact with Sn, Pb targets and generate bremsstrahlung radiation of keV energy and MeV/cm^2 flux. The data produced from Monte Carlo simulation of this system is presented.

1. B. Hidding, K. U. Amothor, B. Liesfeld, H. Schwörer, S. Karsch, M. Geissler, L. Veisz, K. Schmid, J. G. Gallacher, S. P. Jamison, D. Jaroszynski, G. Pretzler, and R. Sauerbrey, Generation of quasi-mono energetic electron bunches with 80fs laser pulses, Phys. Rev. Lett. 96:105004 /2006/
2. P. Zobdeh, R. Sadighi-Bonabi, H. Afarideh, Plasma Devices and Operations, under publication

RCF Imaging Spectroscopy of Laser Accelerated Proton Beams at the Vulcan Petawatt Laser

PO23

F. Nürnberg, K. Harres, M. Schollmeier, M. Roth (TU Darmstadt) S. Bandyopadhyay, D. Neely, D. Pepler (RAL) D. Batani, R. Jafer, R. Redaelli (U Milano) A. Blažević (GSI) D. C. Carroll, P. McKenna, M. N. Quinn (U Strathclyde) S. Kar, K. Markey, M. Zepf (QU Belfast) O. Lundh, G. G. Wahlström (Lund U)

Proton acceleration by ultrashort, high-intensity laser pulses interacting with thin foils attracted high attention in recent years and has been widely examined both experimentally and theoretically. Large numbers of protons are accelerated from the rear side, reaching energies in the multi-MeV-range. These beams have many advantages in comparison to conventionally accelerated proton beams, including low transverse emittance and high brightness as well as short pulse duration. For further applications e.g. in medicine or as a new particle source and pre-accelerator, it is important to have a full characterization of these beams. Properties like proton distribution function (energy and space resolved), divergence, source size, and transverse emittance characterize the quality of this kind of beams. On this poster we present measurements with radiochromic films (RCF) and microstructured gold foils to quantify these properties with a method called RCF imaging spectroscopy.

PO24

Heat transport mechanism in swift heavy ion irradiated $SrTiO_3$

O. Osmani, B. Rethfeld (TU Kaiserslautern) M. Schleberger (U Duisburg-Essen)

After the irradiation of insulators of the perovskite type with an MeV ion beam under glancing incidence periodic nano patters on the surface can be observed. Ab initio assisted calculations for the model system 100MeV Xe –> $SrTiO_3$ will be presented. For this system the electronic energy loss is calculated and used to compute the electronic excitation induced by the primary ion. The heat transport into the lattice away from the track core is performed in terms of the two temperature model.

PO25

The Effect of Large Incidence Angles on Ion Acceleration in Thin Foils by Femtosecond Laser Pulses

J. Psikal (Czech TU, CELIA) V. T. Tikhonchuk (CELIA) J. Limpouch (Czech TU)

Recent theoretical analysis, numerical simulations and experiments have revealed a fast electron current along the target surface layer when a short laser pulse with a relativistic intensity is incident on a planar target at a large angle. In this case, strong quasi-static magnetic and electric fields are generated at the surface layer. They confine the electrons in a potential well near the target surface and the electrons are resonantly accelerated by wiggling inside the static fields and laser fields. Previous papers related to a flat foil were concentrated entirely on a transport of electrons along the target surface, whereas our objective is to investigate the effect of the surface guiding of electron current on a fast ion emission in the foil by using 2D PIC simulations. Two simulations were performed, the first with a small (30°) and the second with a large (75°) incidence angle of an intense femtosecond laser pulse on a foil. For moderate incidence angle typical for many previous experiments, the ion acceleration is the most efficient on the rear side of the foil in agreement with observations. For incidence angle of 75 degree, an effective ion acceleration is demonstrated from the edge of the foil in the direction of the laser wave vector projection onto the front target surface.

PO26

Neutralization of the Ion Track Core in SiO_2

O. N. Rosmej, S. Hagmann (GSI) J. Rzadkiewicz, A. Gojska (SINS Swierk) A. E. Volkov (RRC Kurchatov) A. Sengebusch, H. Reinholz, G. Röpke (U Rostock)

The K-shell spectra of solids irradiated with swift heavy ions can be used for investigations of the parameters of the electronic excitation in the track core. Indeed, production of K-shell vacancies in ion-atom collisions occurs at impact parameters of the atomic K-shell size. The radiative transitions of bound electrons into produced vacancies in the femtosecond time scale give rise to the characteristic K-shell spectra. Therefore temporal and spatial scale of the K-shell radiation is well defined. The K_α X-ray emission spectra of the low-density SiO_2 foam target bombarded by ^{48}Ca ions with initial energy of 11.4MeV/u was measured by means of high resolution X-ray spectroscopy technique. The use of low density stopping media increases the ion range up to 100 times in comparison with solid quartz providing a good spatial resolution of the ion stopping dynamics. Analysis of the Si K-shell experimental spectra demonstrates that neutralization of the ionized track core occurs in the femtosecond time scale. Results of Multiconfiguration Dirac-Fock (MCDF) calculations of the energies of the L-shell satellite groups with respect to the $K_\alpha L_0$ and Monte-Carlo simulations of the K- and L-shell vacancies production will be discussed.

First Set of Diagnostics for the LMJ

PO27

R. Rosch, C. Reverdin, G. Soullié, D. Aubert, J. Baggio, J. L. Bourgade, J. Y. Boutin, T. Caillaud, C. Chollet, S. Darbon, D. Gontier, H. P. Jacquet, J. P. Jadaud, O. Landoas, R. Marmoret, I. Masclet-Gobin, H. Maury, J. Raimbourg, A. Richard, I. Thfoin, P. Troussel, G. Turk, B. Villette, C. Zuber (CEA-DAM)

The Laser MegaJoule (LMJ) facility, now under construction at CEA/CESTA, will be with the National Ignition Facility (NIF) one of the world's largest laser fusion facilities. We present here the design of the first set of diagnostics to be implemented on LMJ. This set includes three imaging diagnostics with high spatial, temporal and spectral resolution. They will give basic measurements, during all the life of the facility, such as position, structure and balance of beams, but they will also be used to diagnose implosions in indirect drive. The design requires components to operate in environments far more severe than those encountered in present facilities. This harsh environment will be induced by fluxes of neutrons, gamma rays, energetic ions, electromagnetic radiations, and in some cases debris and shrapnels, at levels several orders of magnitude higher than those experienced today. The design includes this vulnerability approach. Performances, design and main mitigation techniques will be presented.

Optical Probing Diagnostics of Laser Produced Plasma by Three-Channel Polarointerferometer

PO28

A. A. Rupasov, E. A. Bolkhovitinov, I. A. Krajushkin, A. S. Shikanov (LPI RAS) S. Barnwal, Y. B.S. R. Prasad, P. A. Naik, M. P. Kamath, A. S. Joshi, D. Gupta (RRCAT Indore)

The newly developed scheme of three-channel polarointerferometer has been used for the measurement of electron density profile and magnetic fields structure in laser produced plasma on the laser facility at Raja Ramanna Centre for Advanced Technology, Indore, India. Heating laser pulse of neodimium glass laser with the energy 5J and duration 600ps was focused on the plane surface of solid aluminium targets at the flux density of $5{\cdot}10^{13}$W/cm^2. As the probing beam in the direction perpendicular to the heating beam the radiation of the second harmonic of the general frequency has been used. The probing optical diagnostics had three channels – shadow, interference and polarization ones – with simultaneous registration of all the three images onto the only matrix of a digital camera. Comparison of local intensities of plasma images taken in shadow and polarization channels allows to reconstruct spatial distribution of polarization plane rotation angle of probing laser beam. In turn, processing of images in the interference channel allows to reconstruct spatial distribution of electron plasma density. And, at last, joint processing of distributions of a rotation angle and plasma density enables to reconstruct the spatial structure and intensity distribution of magnetic fields in plasma. The optical scheme, the examples of registered images and reconstructed profiles of electron density and magnetic fields are presented. The work has been supported by ILTP Project A-3.40 and Russian Foundation for Basic Research, grants 05-02-17873 and 08-02-01394.

PO29

Experimental Investigation of Spectral-Angular Distribution of Fast Protons from Rear Side of a Target on the SOKOL-P Laser Facility

K. V. Safronov, A. V. Andriyash, D. S. Gavrilov, S. A. Gorokhov, D. A. Dmitrov, A. L. Zapysov, A. G. Kakshin, I. A. Kapustin, E. A. Loboda, V. A. Lykov, A. V. Pronin, V. N. Sanzhin, V. N. Saprykin, P. A. Tolstoukhov, A. A. Ugodenko, O. V. Chefonov, M. N. Chizhkov (RFNC VNIITF)

In this work the results of experiments on spectral-angular distribution of protons accelerated at rear side of a target are presented. The experiments were performed on the 10TW picosecond SOKOL-P laser facility using high contrast laser pulses with intensities of $\sim 10^{19}$W/cm^2. The targets were thin alluminum foils and combimations of Al and hydrogenous materials. Influence of laser irradiation conditions on parameters of ion beam from target rear side is shown.

PO30

Microtarget Fabrication Techniques, Metrology and Target Handling for the GEMINI High Repetition Rate High Power Laser at RAL

G. Schaumann, C. Spindloe, M. Tolley (RAL)

The GEMINI upgrade of the Astra laser at RAL is to be completed in 2008 and has an experimental repetition rate of one shot every 20s, delivering two beams with ∼15J in 30fs each. With respect to currently operating high energy laser systems, this increase in shot rate by almost two orders of magnitude, requires a different approach in both target manufacturing techniques and target insertion for the experiment. The key issues are addressed within the RCUK (Basic Technology) funded LIBRA project and we will present ongoing research and development in the realm of precision micromachining, photolithography, wafer-based manufacturing and automated target delivery systems.

PO31

Simulation Studies of Direct Drive Heavy Ion Reactor-Size Inertial Fusion Targets

M. C. Serna Moreno, J. J. López Cela, A. R. Piriz (U Castilla La Mancha) N. A. Tahir (GSI) D. H.H. Hoffmann (TU Darmstadt)

Various aspects of heavy-ion-beam Inertial Confinement Fusion are described. Heavy ion beams are very attractive driver for power stations generating inertial fusion energy. It must be investigated the system characteristics of a fusion reactor based on a heavy accelerator as the driver facility and the identification of problems. Many of the features of a reactor design could depend on wether single or double shells targets are employed. We persent simulations of ion beam compression of matter using single and double shell targets.

PO32

On the Modeling of Thermodynamic Properties of Dense Multicharged-Ion Plasmas Based on the Chemical-Picture Approach

A. A. Shadrin, P. A. Loboda, V. V. Popova (RFNC VNIITF)

Consistent modeling of EOS of dense plasmas in the warm-dense-matter domain, is still one of the challenging problems to be addressed. Using the chemical-picture representation [1,2] of plasmas as a mixture of various ions and free electrons, a consistent description of EOS of dense multicharged-ion plasmas is being developed that involves: effects of Coulomb non-ideality and degeneracy of plasma electrons; contribution of possible bound ion states (on the base of the superconfiguration approach [3]) that may exist under an appropriate truncation of ion energy spectra due to plasma effects; hard-sphere-model representation of the finite-volume effects of plasma ions [2] with the model parameters (effective ion

sizes) corresponding to superconfigurations yielding the greatest contribution to partition functions. The model was sampled for Al. We present the calculated data for average ionization, pressure, and specific internal energy of Al plasmas at the temperatures 10-100eV and densities 0.001-5 of normal density. Calculated shock Hugoniots for standard-normal-density Al are compared with other theoretical data and experimental results obtained at RFNC VNIIEF and RFNC VNIITF in 80-90ies at the pressures P>1TPa.

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2. V. K. Gryaznov, I. L. Iosilevsky, V. E. Fortov, Thermodynamic properties of shock-compressed plasmas represented with the chemical-picture model. Shock waves and Extreme States of Matter, Nauka, Moscow, /2000/ in Russian
3. J. Oreg, A. Bar-Shalom, M. Klapisch, Phys. Rev. E. 55, 5874 /1997/

Micropinches in Laser Induced Moderate Power Vacuum Discharge

PO33

A. S. Shikanov, I. V. Romanov, A. A. Rupasov (LPI RAS) V. L. Paperny (Irkutsk SU)

Studies of X-ray emission from a laser-induced vacuum discharge of moderate storage energy (≤20J) are examined. The experimental results are compared with data of the PIC simulations and a fair agreement between them is found. We use the model of a current-carrying plasma jet expanding into the vacuum ambient, which has been developed principally earlier but here we take into account the electron heat conduction. Formation of the micropinch according to both parameters of the pre-plasma produced with the initiating laser pulse and amplitude of the discharge current was also studied numerically. Both experiment and simulations demonstrate that enhancement of amount of the pre-plasma causes a displacement of the micropinch apart the cathode, in the process the energy content in the micropinch plasma declines. If amount of the pre-plasma is too large, then the neck being formed due to a magnetic compression is carried away by the plasma flow beyond the inter-electrode gap and a micropinch has no time to arise. It was found that formation of micropinch in a cathode plasma jet expanding into a vacuum ambient differs significantly from that occurring in a 'classical' high current spark. Namely, at high amplitude of the discharge current the micropinch formation occurs well before the current attains its maximum, nevertheless the high values of the plasma density and temperature are achieved in the case. The work has been supported by Russian Foundation for Basic Research, grants 06-02-16741 and 06-08-01484.

A Miniature Electron Beam Pumped Laser

PO34

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The 1.73μm XeI laser has been operated in a fully continuous mode using a novel, table-top electron beam pumped laser setup. A 12keV electron beam sent through a 300nm thick silicon nitride membrane into a laser gas mixture of typically 600mbar gas pressure was used for pumping. A low loss cavity was installed, resulting in a very low pumping power of 37mW to reach laser threshold. The geometrical conditions for the laser setup such as the shape of the beam pumped volume and its overlap with the optical mode volume are discussed. The laser scheme has been clearly identified as a recombination laser scheme by operating the laser in pulsed mode and observing the time structure of the laser pulse.

PO35

Cryogenic Targets for the LAPLAS Experiments: Fabrication, Manipulation and Survival Study

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HEDgeHOB collaboration plans to carry out a set of experiments at the future FAIR facility at Darmstadt in the field of High Energy Density (HED) matter generated by heavy ion beams. One line of research has been named, LAPLAS (LAboratory PLAnatory Science) [1]. This scheme proposes low-entropy compression of a material like frozen hydrogen or deuterium ice that is enclosed in a cylindrical shell of a high-Z material like gold or lead. Such type of experiment is suitable for studying the problem of hydrogen metallization or for creating physical conditions that are expected to exist in the interiors of the giant planets. First attempt to the cylindrical cryogenic targets fabrication and delivery has been done in the frame of GSI-LPI-HEDgeHOB contract 'Design and feasibility study on fabrication and manipulation of HEDgeHOB cryogenic targets' [2]. This paper presents a thorough analysis of different possible approaches to preparation of cylindrical cryogenic targets for the LAPLAS experiments. The researches are carried out in the following directions: target fabrication, target manipulation, and target survival. On the basis of the performed research, the technical requirements to the corresponding specialized cryogenic system (SCS) were defined. The SCS conception aimed at the potential risks minimization during the system designing and functioning is discussed.

1. N. A. Tahir et al. Phys. Rev. E 63, 016402-1 /2000/ Nucl. Instr. Meth. in Phys. Res. A 544, 16 /2005/ High Energy Density Phys. 2, 21 /2006/
2. I. V. Aleksandrova et al. 35th Conf. Plasma Phys., Russia /2008/

PO36

Practical Models for Femtosecond Diagnostics of Al Plasma

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The description of the transient plasma created by the action of intense laser pulses on a surface of Al target requires detailed models for transport, optical, and thermodynamic properties of the substance. Several models, which are applicable in a wide range of densities and temperatures, are proposed. The free parameters included to the models fit experimental data on the material properties such as the reflectivity at high-temperature conditions. Furthermore, first-principle calculations are performed to obtain the dynamic collision frequency for scattering of electrons on both ions and phonons in a dense strongly coupled system. Green function techniques are used to account for many-body effects such as strong collisions and dynamic screening. A comparison of new results with earlier approximate expressions is presented. We apply the models to femtosecond diagnostics of laser-induced Al plasma. In particular, using the two-temperature hydrodynamic model with a wide-range equation of state, we obtain space- and time-resolved distributions of the plasma parameters (e.g. density, temperature, and composition).

PO37

The Mixing Zone Growth Laws Based on the Evolution Theory and Evaluation of Neutron Yield Decreasing

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The 1D, 2D and 3D calculations of laser spherical targets have been treated numerically and theoretically. It is shown that a mixing zone developed between an inertial shell and a condensed or gaseous thermonuclear fuel has some peculiar features. Initial spectrum of the compressed

shell perturbations is essential due to irradiation inhomogeneity or imperfection of a target preparation. The development of a mixing zone is to be made within the frame work of an evolution theory based on the following concepts. A complex initial perturbation is represented as a superposition of single (individual) perturbations having a definite wavelength and amplitude. Each of the perturbations is developed independently. The evolution of a single perturbation may be described by interpolation of the initial linear instability stage and a later asymptotic stage characterized by damage of 'jets' and a constant supernatant velocity of 'bubbles'. Total width of the mixing zone is determined by a respective contribution of single perturbations. At earlier stages of a mixing the width of a zone is determined mainly by short-wave perturbations. But at later stages the long-wave perturbation are more effective. Based on the above ideas we have proposed an analytical model for the mixing zone width prediction, which proved to be true in numerical experiments. Such the information allows to estimate a neutron yield decreasing, which turns to be close to the 2D simulation one. Note that initial spectrum of perturbation has evidently been taken into account in the proposed theory.

Large Thickness Layers from Initial Rayleigh Density Profiles by Directed Nonlinear Force Driven Plasma Blocks for Alternative Fast Ignition

PO38

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After measurement of extremely relativistic new phenomena at interaction of >TW-ps laser pulses with plasmas, a drastically different anomaly was observed if the laser pulses were very clean with a contrast ratio of higher than 10^8 for suppression of pre pulses of less than dozens of ps before arrival of the main pulse, for suppression of relativistic self-focusing. This anomaly was confirmed in many experimental details and explained and numerically reproduced by nonlinear force acceleration of skin layers generating plasma blocks with space charge neutral ion current densities above 10^{11}A/cm^2 [1]. This may support the requirement by Steve Dean [2] to produce a fast ignition DT fusion at densities not much higher than the solid state by a single shot PW-ps laser pulse. After the ignition conditions are being re-evaluated in due course [3] we are studying numerically how double Rayleigh initial densities can results in many wavelength thick low reflectivity directed plasma blocks of modest temperatures. First results of computations with the genuine two-fluid model are presented.

1. H. Hora, J. Badziak et al., Physics of Plasmas 14, 072701 /2007/
2. S. O. Dean, J. Fusion Energy 27, No.4 /2008/ available from http://springerlink.metropress.com or IFE_whitepaper.pdf
3. M. Ghoranneviss et al., Laser and Particle Beams 26, 105 /2008/

An Improved Double-Pulse Non-normal Incidence Pumping Geometry for Transient Collisionally Excited Soft X-ray Lasers

PO39

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An optimized pumping scheme for transient collisionally excited soft X-ray lasers is presented. In contrast to usual approaches, where a nanosecond pre-pulse is assumed to provide the optimal plasma preparation and a picosecond pulse performs the final heating- and excitation process, two pulses of equal duration in the range around 10 picoseconds are applied. Both pulses are produced by a Mach-Zehnder set-up in the front-end of the laser system and then, collinearly to the main pulse, propagated through the amplifiers and the compressor, which radically reduces the complication of the beam delivery. They are focused onto the target with the same spherical mirror under non-normal incidence geometry with an optimized GRIP angle for the pump laser wavelength of 1.053μm. A first experiment was performed on Ni-like palladium (14.7nm) at less than 500mJ total pulse energy on the target, confirming the advantage of this pumping scheme which eliminates the tedious alignment required for the two-beamline geometry. This simplification of the XRL pumping scheme, which is especially appealing to large aperture systems, opens the way for the improvement of XRL in high repetition-rate facilities like LASERIX. The possibility for efficient operation at pulse durations above 20ps can be used for a further reduction of pump laser requirements for applications. The simplified geometry will also ease the application of higher pumping pulse energies, which is still necessary for reaching shorter XRL wavelengths.

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