Progress in laser-ion acceleration for medical applications

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Recent experiments demonstrated for the first time lasesr-ion acceleration to medically relevant energies. Specifically, > 160 MeV protons, with indications of up to 200 MeV energies, have been measured in multiple experiments at the LANL Trident laser. The results are in good agreement with published models of acceleration in relativistically transparent plasmas, aka “Break-Out Afterburner (BOA) acceleration”. This same mechanism has by now also been observed on other facilities, e.g. the Texas Petawatt Laser and GSI’s Phelix laser. The theory is shown to be both robust and predictive allowing scaling calculations for future systems.

At the same time we are addressing the main bottle neck of the high energy Nd:Glass laser systems required, i.e. there repetition rate, which is typically 1 shot per hour. AT UT , we are currently developing a Trident class, few hundred TW, ~100J system glass laser system with a repetition rate of ~3Hz. The implications of this recent progress in both mechanism understanding and laser systems for the target technology required for a medically relevant prototype are discussed.

Laser Acceleration of Protons and Ions at Salamanca

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A series of experiments aiming to accelerate protons and light ions with lasers of ultra-high intensity is currently under preparation at Salamanca (Spain).** The host institute, the Spanish Pulsed Laser Centre (CLPU), is a national facility providing several high-power lasers for research as well as industrial applications. Two of its VEGA lasers, with 20 and 200 TW pulsed power, are currently equipped for laser-plasma experiments. The third phase of VEGA with 1 PW pulsed power will be operative at the end of 2014. The Institute for Instrumentation in Molecular Imaging (I3M, Valencia) is contributing to the experiments with particle detectors for the characterisation of the accelerated ions as well as suitable laser targets. The third partner of our collaboration, the spin-off company Proton Laser Applications (PLA), is developing compact and innovative, high-power laser systems.

Our principal goal is to provide equipment for medical applications such as the production of radiopharmaceuticals. Many short-lived isotopes are currently produced at relatively large cyclotron facilities. Compact, laser-based ion accelerators are a promising alternative. Since this technology is expected to be cheaper and of smaller size, laser-driven devices may be installed in close vicinity to the treatment centre and allow for a cost-effective fabrication of a broad range of medically relevant isotopes. Their realisation requires the development and optimisation of many components of the setup. Our initial goal is to demonstrate the acceleration of large numbers of protons to sufficiently high energies (around 10 MeV). This basic research will be conducted at the CLPU lasers. In parallel, PLA is developing a novel laser source with high energy and repetition rate.

We present in detail our experimental setup, the contributions of the three collaborators, and first test results of our particle detectors.

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Thickness determination of free-standing nm-targets

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Technical laser development to ultrahigh laser contrast enabled the high field laser community to use ultrathin foil targets (below 200nm). The scientific interest in these ultrathin foils increased during the last years as theoretically predicted and experimentally found acceleration mechanisms beyond the Target Normal Sheath Acceleration (TNSA) process.

A key scenario is the Radiation Pressure Acceleration (RPA), which is still under scientific investigation – as it promises acceleration to higher ion energies as the TNSA process. For the RPA, targets thickness and density has to be scaled to the used laser intensity, therefore these are crucial parameters for the used freestanding foils.

We present a versatile and handy method allowing a thickness determination of freestanding thin plastic foils by its transmission characteristics in the EUV spectrum. The method is based on a laser induced plasma source, emitting light in the extreme ultraviolet (EUV) region. A compact double-mirror EUV monochromator selects sharpgly a fixed wavelength of 18.9nm and a CCD camera providing high dynamic range for transmission values with a standard deviation of $\Delta T = 0.005$. This enables foils thickness characterization with nm-accuracy at a given foil density and stoichiometric composition.

In comparism to height sensitve methods like AFM, confocal micrsopy or polymetry, the foil thickness can be determined and mapped directly on the freestanding foil[1], already mounted in the needed target holder for the laser plasma interaction experiment.

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Transition in proton energy scaling with linearly polarized laser pulses

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Particle acceleration using ultraintense, ultrashort laser pulses is one of intensively investigated topics in relativistic laser-plasma research. We investigated proton/ion acceleration in the intensity range of 5×10^{19}W/cm^2 to 3.3×10^{20} W/cm^2 by irradiating linearly polarized, 30-fs, 1-PW laser pulses onto 10- to 100-nm-thick polymer targets. The proton energy scaling with respect to laser intensity and target thickness was examined. The experimental results clearly showed, for the first time with a linearly polarized light, the transition of proton energy scaling from square ($\sim I^{1/2}$) to linear ($\sim I^1$), which is a consequence of hybrid acceleration consisting of TNSA and RPA [1]. In addition coulomb explosion assisted the free expansion in the post acceleration stage. A maximum proton energy of 45 MeV was obtained when a 10-nm-thick target was irradiated at the laser intensity of 3.3×10^{20} W/cm^2. The experimental results were supported by two- and three-dimensional particle-in-cell simulations.

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Acceleration and Characterization of Protons and Ions from Nanometer-Scale Thin Polymer Foil

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Interaction of ultra-intense laser with ultrathin foil targets has attracted great interests for the achievements of multi-hundred MeV protons and ions[1], quasi-monoenergetic electron bunches, and bright x-ray beam[2]. In the previous studies, aluminum, Mylar, silicon nitride, and diamond-like carbon have been used as the targets. As a different target material, being novel to the relativistic laser-matter interaction community, we have developed a freestanding, nanometer-scale foil target made of a conjugate polymer material, poly(9,9'-dioctylfluorene-*co*-benzothiadiazole) (F8BT)[3]. The material was spin-coated onto an optically flat substrate to a film thickness of 5–500 nm. The film was floated on water, and then transferred to a special holder having an array of bored holes to provide the freestanding foil target. It has been demonstrated that the target is robust enough to be used for PW laser beam and also efficient for the multi-ten MeV proton acceleration in terms of repetitive single-shot operation, easy fabrication and thickness control, and relatively cheap production cost. The ion acceleration experiments have been systematically performed using our well-established laser-target interaction system[4] which enabled tight focusing of PW laser beam, precise alignment of the target within a few tens of ㄴ m, and characterization of the ions. With the application of well-characterized PW laser pulses, the ultrathin foil targets have been proven to be very effective in generating protons and ions with energy per nucleon in the range of several tens of MeV.

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Laser ion acceleration with low density targets: a new path towards high intensity, high energy and high current ion beams

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Intense research is being conducted on sources of laser-accelerated ions and their applications, motivated by the exceptional properties of these beams: high brightness, high spectral cut-off, high directionality, laminarity, and short duration (~ps at the source). It was recently shown experimentally that a promising way to accelerate ions to higher energies and in a collimated beam is to use under-dense or near-critical density targets instead of solid ones. In this case, volume effects dominate, enhancing the laser-to-proton energy conversion, and allowing to reach high ion energies with a high number of accelerated ions. This scheme also leads to less debris than solid foils and is adapted to high repetition lasers. Under certain conditions, the most energetic protons are predicted to be accelerated by a collisionless shock mechanism that significantly increases their maximum energy.

The transition between various laser ion acceleration regimes depending on the density gradient length (controlled by the delay between the lasers) was studied at LULI in May 2011 using a two-laser setup. A first ns pulse was focused on a thin target to explode it and a second laser (350 fs pulse duration, high intensity) was focused on the exploded foil. Protons with energies close to the ones reached using solid targets were obtained for various exploded foil configurations with ~5 J of laser energy. As this regime scales well with laser energy, new experiments were performed in 2012 with more laser energy (~180 J) on the LLNL Titan laser with a similar setup. In this high energy regime, protons with energies significantly higher than the ones reached for solid targets were obtained while keeping a good beam quality. These results demonstrate that low-density targets are a promising candidate for an efficient compact proton source. This source can be optimized by choosing appropriate plasma conditions.

Robust energy enhancement of ultrashort pulse laser accelerated protons from reduced mass targets

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We present a systematic study of the ultrashort pulse laser driven acceleration of protons from thin targets of finite lateral size, so-called reduced mass targets (RMTs). Reproducible series of targets varying in size, thickness, and mounting geometry were manufactured with lithographic techniques. Irradiating these targets at the 150 TW Draco Laser facility of the Helmhotz-Zentrum Dresden-Rossendorf with ultrashort (30 fs) laser pulses of intensities of about 8×10^{20} W/cm^2, a robust maximum energy enhancement of almost a factor of two was found when compared to reference irradiations of plain foils of the same thickness and material. Furthermore, these targets exhibit a reduced performance dependence on target thickness compared to standard foils, which, based on detailed PIC simulations can be explained by the influence of the RMT geometry on the electron sheath. The performance gain was, however, restricted to lateral target sizes of about 50 μm which was attributed to edge and mounting structure influences. The contribution of the large electric fields at the target edges to the proton acceleration performance was investigated with measurements of the proton beam profile as well as optical pump and probe experiments.

Sub-micrometer spheres for laser driven ion acceleration

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The Enhanced-Target Normal Sheath Acceleration (ETNSA [1, 2]) mechanism has been demonstrated in three different experimental campaigns performed at APRI-CoReLS ultraintense femtosecond laser facility. Sub-micrometer polystyrene spheres have been placed at the target front-side in order to enhance the laser absorption and, as a consequence, the number and temperature of the accelerated hot electrons. Such increased laser conversion mechanism at the foil front-side resulted in an increase of maximum energy and total number of the accelerated protons emerging from the target rear-side. Presented results have been obtained by using laser intensities ranging from $5x10^{19}$ W/cm^2 up to $5x10^{20}$ W/cm^2 and plastic targets with an effective thickness of about 1 μm. Experimental results and comparison with particle-in-cell numerical simulations are presented and discussed.

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Cryogenic target development for high-repetition rate solid H2 and D2 targets

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With the development of new petawatt in many countries, new needs for targets appear. In this context the development of a proper target system reliable for operating at 1-10 Hz repetition rate is needed. Furthermore, there is a high scientific interest in investigating the possibility to use “solid hydrogen” thin foils since they can allow producing well defined, high current proton beams, reducing the shot-to-shot fluctuations which are typical for laser-accelerated proton beams (typically the H content comes from target impurities). Thus, the main goal of this scientific and technological topic is to design, develop and test (in various operating high power laser facilities) a system for “solid H” target delivery. The applicability of laser driven proton beams in various fields (Medicine, Biology, Material Science, Chemistry, etc.) being the eye tumor a “demonstration case”.A research program based on “Particle Acceleration by Laser” is born at CEA/INAC/SBT (Low Temperatures Laboratory)

Cryogenic engineering has for a long time been identified as a key technology in the missions of CEA for fundamental or applied research activities. Particle Physics, Astrophysics, Magnetic and Inertial Fusion and Laser are fields of Physics which need complex equipment or large infrastructures where cryogenics is one of the key issues. In this context, SBT (with 60 persons, half engineers and technicians) targets to serve the national and international research community by providing expertise, unique prototypes and specifically designed devices building upon the know-how derived from 50 years of cryogenic engineering.

SBT was in charge since 1994 to develop the “cold chain” for cryogenic targets for inertial fusion, or simulation of thermonuclear weapons (LMJ or NIF programs), or power production (IFE program, HiPER project). The SBT is able to provide:

Very complex systems working at 15 K (or less) with of 1 mK stability for Hydrogen solidification,

Robotics able to work in a cryogenic environment (loading, targets transfer),

Targets positioning with an accuracy of 15 microns in an experimental chamber of 10 meters diameter.

SBT wants to value its technical and scientific experience in the field of particles acceleration, and to obtain high energy protons is a new topic and challenge in which we are now involved since last year. This talk will presents the capabilities of CEA/INAC/SBT and the technical program for the period 2014-2017.

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Thin cryogenic hydrogen targets for laser-driven ion acceleration

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Target composition and geometry play a crucial role in laser-plasma interaction experiments. With the recent availability of large temporal contrast ratios at high power laser facilities the use of ever thinner targets becomes desirable. Simulations of new laser driven particle acceleration regimes exploiting these targets (e.g. radiation pressure acceleration (RPA) [1] and laser breakout afterburner (BOA) [2]) predict particle energies in the GeV range in contrast to tens of MeV achievable in present target normal sheath acceleration (TNSA) experiments.

In this contribution we will present our efforts to produce micrometer-sized cryogenic targets from pure hydrogen in foil-like geometry as well as polymer films with thicknesses of some hundred nanometers. While cryogenic hydrogen targets serve as pure proton sources and thus could provide very high proton energies, polymer targets with a carbon to hydrogen content ratio of 1:2 still provide high proton energies while being beneficial in terms of handling. According to particle in cell code (PIC) simulations both types of targets are expected to deliver laser driven particles with several hundred MeV per nucleon. Possible applications of these high energy particle beams include proton driven fast ignition [3] and the production of secondary particle beams such as neutrons [4]. Cryogenic hydrogen targets could also be used in high energy density experiments with swift ions produced by either lasers or conventional accelerators [5].

We will give an overview of target production and characterization at the Technische Universität Darmstadt as well as recently performed experiments at the PHELIX laser facility at the GSI Helmholtzzentrum für Schwerionenforschung GmbH. The project is supported by the Federal Ministry of Education and Research (BMBF) of the Federal Republic of Germany and the European High Power Laser Energy Research (HiPER) project.

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Solid hydrogen micro spheres for laser proton acceleration

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Solid hydrogen micro spheres have been used as internal targets for storage rings since the 1990ies (e.g. [1]). But due to their dimensions and low spatial stability, these pellet generators are of low value for laser plasma interaction experiments, where high spatial and temporal stability of the hydrogen droplets is required.

Here we present our approach of a compact cryogenic source [2] for laser plasma interaction experiments. The cryogenic source is delivering 9 µm sized hydrogen pellets at a repetition rate of 2 MHz with high spatial and temporal stability.

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Production of low-density targets for laser driven ion acceleration

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The performances of laser-driven ion acceleration [1] can be enhanced controlling laser-matter interaction through the design of suitably engineered targets. In this work we report on the production and testing of low-density targets to be adopted in novel laser driven ion-acceleration experiments exploring enhanced acceleration regimes.

As a possible way to enhance the maximum energy of laser-accelerated ions in the Target Normal Sheath Acceleration (TNSA) scheme, multi-layered targets having a near-critical density layer on the directly illuminated surface have been recently numerically investigated [2]. Low-density carbon foams can also be exploited in other acceleration schemes, like Hole-Boring Radiation Pressure Acceleration and Collisionless Shock Acceleration. Because of their extremely low density (few mg/cm^3 for laser wavelengths around 1 µm) and the possible request of good adhesion to the solid surface, the production and characterization of these targets is not straightforward.

In this frame, we report on the production of low density carbon foams by Pulsed Laser Deposition with thickness in the range 5-150 µm and densities down to 3-5 mg/cm^3. Foams were characterized through Scanning Electron Microscopy and Raman Spectroscopy [3] and their density was evaluated exploiting Energy Dispersive X-ray Spectroscopy. In particular, both nearly freestanding foams and multi-layered targets composed by a thin Al solid foil (0.7-12 µm) and a near-critical density carbon foam layer directly grown of its surface have been produced.

Laser-ion acceleration experiments employing multi-layered targets have been carried on at the UHI100 system, at CEA Saclay, within the frame of Laserlab EU program. For relatively low laser intensities (10^{16}-10^{17}W/cm^2), a systematic enhancement of the maximum ion energy has been observed in presence of the foam layer, allowing to reach the MeV range. More generally, the results of a parametric analysis of a wide number of target-laser interaction conditions will be presented.

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Innovative handling and transport solutions for laser-driven ion beams

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Nowadays, laser-driven proton beams generated by the interaction of high power laser with solid targets represent a fascinating attractive in the field of the new acceleration techniques. In the last decades a great effort, both from theoretical and experimental point of view, has been devoted to charged particle acceleration using high power lasers. Several acceleration regimes have been investigated so far in literature aiming to overcome the experimental limits achieved up to now and to generate proton beams characterized not only by very high intensity and high energy but also by small energy and angular spread [1-7]. Moreover, in order to characterize in terms of focusing, transmission and energy selection the laser-generated ion beams and to make them suitable for multidisciplinary applications, investigating also the possibility of using laser-driven proton beams in the clinical field, an adequate beam transport line must be developed and tested.

In the framework of the ELIMED project [8], we started to design and realize a first prototype of a beam transport line (BTL) that will allow to deliver laser-accelerated proton beams with optimize properties and sufficient repetition rates in order to perform first dosimetric and radiobiological irradiations with such kind of beams [9-10]. In particular, we have already developed a first prototype of a key element of the beam transport system, i.e. an Energy Selector System (ESS), based on permanent dipoles, capable to control and select in energy laser-accelerated proton beams. Montecarlo simulation and some preliminary experimental tests have been already performed to characterize the device. A calibration of the ESS system with a conventional proton beam will be performed in September at the LNS in Catania.

In this contribution a description of different solutions studied for the BTL development depending on transmission efficiency and on energy spread and preliminary ESS calibration results together with the Monte Carlo simulations performed on the ESS will be discussed.

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RAL High Accuracy Microtargetry System

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The challenge of positioning laser targets at high repetition rates increases as laser technology and laser repetition rates improve. Higher repetition rates allow experiments to be completed in a shorter time and, potentially, allow high repetition rate systems to be used as particle sources/beamlines. Ultimately the aim is to produce reliable and accurate target positioning for 10Hz lasers.

The CLF are working towards this ultimate goal in phased developments. The initial specification for the HAMS is to deliver pristine targets and align them to the focal spot and plane within the shot rate of Gemini (0.1Hz). The accuracy specified for the positioning of targets is ±4μm for Z position and ±10μm for the X and Y motion. The HAMS system uses targets mounted on wafer segments located in 1° steps on 2 annuli giving 688 targets and 2 hours of operation.

Phase one methodology for HAMS is to align one target precisely to the focal spot and beam in all degrees of freedom. The wafer segment wheel can then be sequentially rotated through 360° to position each target within tolerance. Development of the wafer mounting and the precision of motion control stages is underway to ensure that the accumulation of all possible errors is smaller than the tolerable positional range.

Phase two methodology for HAMS is to integrate the motion control stages with an automatic target alignment system also being developed within CLF (discussed in a separate paper) which will enable real time automatic positioning of targets.

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Microtarget Mass Production for the RAL High Accuracy Microtargetry System

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Recent and future developments in High Power Laser science are pushing repetition rates to levels of 1Hz and above. Systems such as Astra Gemini at Rutherford, the planned HIBEF beamline at DESY and the ELI systems will carry out fundamental research on a range of experiments which will drive a large increase in the target numbers that are consumed.

To deliver target solutions to this requirement, Scitech Precision Ltd. in collaboration with the CLF has developed a range of fabrication processes based upon those used for Micro-Electro-Mechanical System (MEMS) manufacture. This allows wafer-scale fabrication where each wafer may hold arrays of several thousand individual laser targets. A target manufacturing run of a number of wafers could therefore provide sufficient targets for a typical experimental campaign even when shot at high repetition rates and could provide a robust and simple target holding and delivery system for other pick and place assembly solutions

This presentation will describe the fabrication processes and how they are combined to create a range of laser targets. It will conclude by describing how these target arrays are integrated into the RAL High Accuracy High Throughput Microtargetry System (HAMS).

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Sub-micron accuracy target alignment

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The drive to ever higher intensities with higher repetition rates and the move to shorter focal length reflective optics for focussing in solid target interactions are increasingly important for studies into high intensity secondary source generation, QED and high field studies. To ensure reproducible optimum interaction conditions, presents a significant problem for accurate target positioning. Commercial optical systems exist to aid the imaging and positioning of targets. However, these are often expensive and difficult to situate within the limited space available inside the interaction chamber.

At the Central Laser Facility, the push for ultra high intensities above I = 10^{21} Wcm^{-2} requires positioning targets within the focussing optic Rayleigh range. We will present details of two systems to be implemented on the Astra-Gemini system to cheaply and accurately position targets with ≈ micron accuracy. These involve; (a) a multi-wavelength interferometer to enable sub-micron accuracy and (b) a small, low cost near field/far field microscope with illumination at 800nm for imaging the rear of the target and the focal plane with high resolution. The combination of these two systems significantly improves our accuracy in target positioning and also results in a decrease in the time required to align targets between shots.

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Laser-Ion Acceleration - Activities in Munich, LEX and CALA

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We currently extend our research capabilities in the framework of the laboratory for extreme photonics (LEX). Amongst the development of a 5 fs, 100 TW-laser, the PFSpro, we will operate our ATLAS laser system which has been operated over decades at the MPQ at a 300 TW level. A further upgrade to ultimately 3 PW peak power becomes possible in the Center for Advanced Laser Applications, CALA, until 2017. As the name intends, the center is dedicated to applications, not only of laser-driven ions, but also laser (and conventionally) accelerated electrons and the brilliant radiation generated by those. My talk will provide an overview over this intriguing project. I will highlight some of the most important developments in the field of laser-driven ion accelerators in Munich, from which we aim to benefit for this great endeavour.

Enhanced laser-plasma proton acceleration using solid foils with attached low density carbon foam

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In the interaction between a high power laser and a thin solid foil, the laser-plasma coupling can be strongly enhanced adding a low density material on the irradiated side, i.e. a carbon “foam”. We investigate by particle-in-cell simulations in two and three dimensions the role played by the density and the thickness of the plasma obtained from the ionization of the foam. The presence of a near-critical plasma strongly increases both the conversion efficiency and the energy of the “hot” electrons leading to enhanced acceleration of protons from a rear side as in a typical target normal sheath acceleration. A moderate self-focusing of the laser beam occurs during the propagation through the foam layer, suggesting an “enhanced” TNSA in the interaction with the solid foid. We found, however, that the electrons of the foam are strongly accelerated in the forward direction and, propagating on the rear side of the target, are the main responsible for building up a high electric field with a relatively flat longitudinal profile. In these conditions the maximum proton energy is up to three times higher than in the case of the bare solid target.

The simulation campaign has been supported by the PRACE project “LSAIL”.

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Cluster-Gas Targets as Efficient Media for Laser-Driven Ion Acceleration

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The laser-driven ion acceleration via the interaction of short, intense laser pulses with matter, known as laser-plasma acceleration, is featured by its high accelerating electric fields and short pulse length compared to conventional rf-accelerators. The recent advancements of novel laser-driven ion acceleration techniques now allow and even exceed the maximum energy of ions up to several tens of MeV. The state of material is a key ingredient here, which determines the characteristics of the interaction, and has to be chosen properly according to the purpose. For example, substantial enhancement of the accelerated ion energies has been demonstrated by utilizing a unique property of a cluster-gas target [1], where submicron-size CO_2 clusters with an average diameter of 220 nm [2] are embedded in background He gas produced by using a three-staged conical nozzle designed based on the Boldarev's model [3]. Numerical simulations indicate that acceleration enhanced by the generation of a quasistatic magnetic field [4,5] was the dominant mechanism, and that the role of the clusters was apparently that of enhancing the self-channeling and focusing of the laser pulse, leading to an increase of the intensity in the plasma, rather than contributing to ion acceleration via cluster explosions. However, the recent experimental result conducted with a high contrast laser indicates that other mechanisms could work [6].

In order to further investigate the underlying physical mechanism of high power laser interaction with cluster medium, we have performed simulations using EPIC3D (Extended Particle based Integrated Code) [7], which includes key atomic processes and relaxation processes self-consistently in fully relativistic three dimensional configuration, and systematically investigated the interaction processes of medium of carbon clusters embedded in helium gas. We found that the synergetic interplay of different mechanisms such as

1) acceleration of ions due to Coulomb explosion of individual carbon clusters,
2) compression and acceleration of background helium gas due to the Coulomb explosion of clusters,
3) magnetic vortex generation and associated pinching near the rare surface,
4) sheath acceleration at the interface between the medium and vacuum,

could play an important role in realizing the particle acceleration observed in the experiments. We also found that a self-organization process resulting from the complex interaction between clusters and background gas regulates the dynamics. More interestingly, in laser intensities of a relativistic ion regime, a new mechanism of ion acceleration can be incorporated with the Coulomb explosion.

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Laser-plasma targetry: smallscale gas jets at a near-critical level

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Recent progress in solid-state laser technologies calls for innovative and controllable targetry to increasingly unleash the tremendous potentialities of laser-plasma sciences. SourceLAB, a young spin-off of the Laboratoire d'Optique Appliquée (France), endeavors to accompany the research effort by developing new solid and gas targets with unique properties [1]. We developed in particular smallscale gas jets of less than one millimeter size and peak density higher than 10^{21} atoms/cm^3 [2]. Rare gases at pressure above 300 bar has been developed for this purpose to compensate the nozzle throat diameter reduction that affects the output mass flow rate. The fast-switching electro-valve enables to operate the jet safely for multi-stage vacuum pump assembly. Such gaseous thin targets are particularly suitable for fine laser-plasma interaction studies in the unexplored near-critical regime, of great interest for plasma astrophysics [3], electromagnetic instabilities studies [4] and particle acceleration [5,6].

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Proton Beams Produced by Laser Interaction in Italy: from the First Experiences at the INFN FLAME Facility toward the Development of a Multidisciplinary Proton Beam Line (ELIMED)

Dario Giove on behalf of LILIA and ELIMED collaborations

The first proton beam emitted by laser interaction in TNSA scheme was obtained in Italy in 2012. The experiment named LILIA (Ligth Ions Laser Induced Acceleration) was carried out at the laser FLAME facility at INFN in Frascati. Details about the laser and target set-up will be described along with the detectors used for the preliminary measurements.

In the frame of LILIA related activities we developed different diagnostic tools. At the same time a fully 3D simulation was performed in order to design a post acceleration scheme of laser induced beams, based on collimators, pulsed solenoids and high frequency linacs.

In 2013 within the objectives of the ELIMED experiment (MEDical applications at ELI-Beamlines) we started R&D activities for the development of a multidisciplinary proton beam line with laser accelerated protons.

The experiences gained both in LILIA and in ELIMED lead to the definition of a common program aimed to develop targets, diagnostic elements, PIC simulations, beam transport design for a 30 MeV beam line.

In the contribution the results obtained up to now and the future developments of the experiment will be presented.