Mini-Workshop on Laser Acceleration of Ions and Neutron Production with Structured Targets

On 6th and 7th March,2019
ELI Beamlines / Room A

Organizers:

- ELI Beamlines, Dolní Břežany, Czech Republic
- Institute of Laser Engineering of Osaka University, Japan

PROGRAMME

March 6, 2019

9:15-9:30 Opening of the workshop
S. V. BULANOV, M. MURAKAMI, D. MARGARONE

9:30-10:10 Masakatsu MURAKAMI (ILE, Osaka University)

"Novel approach to the Schwinger limit: Micro-bubble implosion as a plasma-optical device"

Abstract: We propose a novel principle to approach the Schwinger limit using micro-bubble implosions. Such an implosion can generate an ultrahigh density proton core on the nanometer scale, which results in an ultra- high electrostatic field. A micro-bubble implosion has potential as a plasma-optical device, which optimally amplifies an applied laser intensity by a factor of two orders of magnitude.

10:10-10:50 Jan PSIKAL (ELI-BL, CTU)

"Laser-accelerated energetic protons from specially designed targets"

Abstract: The efficiency of laser-driven ion acceleration strongly depends on the kind of targets used in the experiment. In the last decade, numerical simulations followed by several experiments have demonstrated that specially designed nanostructured solid targets may substantially increase the number and energy of accelerated protons and/or to modify the profiles of generated proton beams in the widely used target normal sheath acceleration (TNSA) regime [1]. We have also demonstrated a high efficiency of proton acceleration from cryogenic solid hydrogen ribbon which is the target where novel acceleration regimes may become dominant more easily compared with other solid targets' composition [2]. In this contribution, our previous achievements on the proton acceleration from thin foils with deposited monolayer of nanospheres on the front (laser-irradiated) side will be summarized and further optimization of the acceleration efficiency from nanostructured targets in TNSA regime will be discussed [3]. Secondly, we will interpret the experimental results showing the manipulation of proton beam profiles by nanostructured rear surface

of the targets [4]. Thirdly, it will be shown with the help of multidimensional particle-in-cell simulations that hole boring radiation pressure acceleration (HB RPA) dominates over the TNSA when multi-PW laser pulse interacts with hydrogen solid ribbon [5].

References:
[1] D. Margarone et al., Phys. Rev. ST – Accel. Beams 18, 071304 (2015).
[2] D. Margarone et al., Phys. Rev. X 6, 041030 (2016).
[3] J. Psikal et al., Phys. Plasmas 23, 123121 (2016).
[4] L. Giuffrida et al., Phys. Rev. Accel. Beams 20, 081301 (2017).
[5] J. Psikal et al., Plasma Phys. Control. Fusion 60, 044003 (2018).

10:50-11:10 Coffee break

11:10-11:50 Hedvika KADLECOVA (ELI-BL)

"Electromagnetic Shocks in Quantum Vacuum"

Abstract: The higher availability of high power lasers makes the experimental observation of processes such like photon-photon scattering more and more possible. We study the non-linear process of photon-photon scattering in vacuum, i. e. interaction of two counter-propagating electromagnetic waves in a vacuum, within the framework of the Heisenberg-Euler formalism in quantum electrodynamics. The main purpose of the study is to analyze the process and the emitted radiation in order to determine conditions for a real experiment in the laboratory with high energy lasers at facilities such as ELI beamlines.

12:00-13:30 Lunch

13:30-14:10 Yasuhiro KURAMITSU (Dep. Electrical Engineering, Osaka University)

"Laser driven ion acceleration with a large-air suspended graphene"

Abstract: We have developed a novel target, a large-area suspended graphene, for ion sources with intense lasers. We give a brief summary of our recent experiments with NCU 100 TW, Vulcan PW, LFEX, and J-KAREN with short F chamber. We discuss the future applications and collaborations to develop the new frontier of laser driven ion sources.

14:10-14:50 Martina ZAKOVA (ELI-BL, CTU)

"Laser-driven ion acceleration: different attitudes to advanced target design depending on a laser contrast (PIC simulations)"

Abstract: Laser-driven ion beams have a great importance since high intensity pulsed lasers were developed. Particle-in-cell simulation of targets with microstructures on its back side will be presented with the main aim to reduce divergence of laser-driven protons or to improve other particle beam parameters and thus fulfill the requirements of foreseen applications with wide socioeconomic impact. On the other hand, in experiments, laser contrast is usually not ideal and corresponding laser prepulse destroys the structures on the front and often on the rear side of the target as well before the main pulse arrives. Naturally, the laser prepulse is widely taken as an unwanted feature and are usually partly filtered out by expensive plasma mirrors. In fact, there is a possibility of different attitude how to deal with the situation and

take laser prepulse as a natural feature, which makes the target expand and decrease its density. 2D Particle-in-cell simulations of such slightly above critical targets (~ 10 nc) will be presented and supported by experimental data measured during laser-driven ion acceleration campaign from hydrogen cryogenic ribbon at VULCAN laser (Rutherford Appleton laboratory, UK). Targets having various density profiles and with preplasma layer will be discussed as well.

14:50-15:10 Coffee break

15:10-15:50 Yasunobu ARIKAWA (ILE, Osaka University)

"Laser driven fast neutron generation and its application"

Abstract: Neutrons radiography has been expected a promising method to investigate inside of objectives, especially large size objectives such as concrete wall. The laser driven neutron radiograph was demonstrated on LFEX facility in Osaka University. As well as single shot experiment, a repetitive laser driven neutron generation and radiograph experiment were also performed using CLPU, Salamanca.

15:50-16:30 Martin MATYS (ELI-BL, CTU)

"Generation of collimated quasi-monoenergetic proton beam using two-layer target and controlled relativistic Richtmyer-Meshkov-like Instability"

Abstract: With the advent of multi-petawatt laser systems like ELI Beamlines, Apollo or SEL, laser-plasma interactions reaches a new field of acceleration dominated by radiation pressure acceleration mechanism, promising laser-driven ion acceleration above several (tens of) GeV. Although a few proposals for the generations of mono-energetic stable ion beams have been made, several drawbacks like, low collimation of the produced beams remain to be solved. Therefore, we propose the use of high-intensity laser and double layer target (consisting of heavy and light material) with initial perturbation on the interface. Using extensive 2D3V PIC simulations, we show that this configuration may result in a development of a relativistic Richtmyer-Meshkov like instability. Initially small perturbations are then amplified during the laser-target interaction leading to the formation of low-density foil ruptures and high-density plasma bunches between them, which are accelerated by the laser radiation pressure as a whole compact structures. The central bunch is then collimated by the laser pulse propagating through the ruptures, preventing from the perpendicular particle movement, resulting in the well-collimated quasi mono-energetic proton beam with the average energy of several GeV.

16:30-17:30 Lab. tour

19:00-21:00 Dinner

March 7, 2019

9:30-12:00 Discussions on the scientific collaboration in theory and experiment between the ELI-Beamline and Osaka University.

12:00-13:30 Lunch

13:30-17:30 Discussions on the scientific collaboration in theory and experiment between the ELI-Beamline and Osaka University.