Ultrashort Laser Pulse Interaction with Target: Ion Acceleration

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Experiments on ion acceleration driven by high intensity lasers over the past ~15 years have demonstrated the generation of multi-10s of MeV proton and ion beams with remarkable properties such as ultrashort burst emission, high brilliance, and low emittance over a wide range of laser and target parameters.

Nowadays the laser peak power can reach several petawatts (PW) and the intensity above 10^{22} W/cm^2 can become available for experiments. Thus, an entirely new area of research, the regime of relativistic plasma physics became accessible in the lab. To explore the interaction physics in these novel intensity regime is one of the most exciting goals of current high field research. After short survey of relevant background, this presentation will discuss the recent experimental findings on ion acceleration obtained on PW laser.

In most laser-driven ion acceleration studies the sheath field established by relativistic electrons at target surface accelerates ions via the so-called Target Normal Sheath Acceleration (TNSA). A separate mechanism, Radiation Pressure Acceleration (RPA) where radiation pressure is exerted via laser ponderomotive force on a foil surface, which results in electron-ion displacement and ion acceleration via the ensuing space-charge field. At PW laser power a new scenario was found, which offers more favorable proton energy scaling with laser intensity than “ordinary” TNSA. The ions are accelerated in the electrostatic field of charged cavity created by relativistic laser pulse at the target front and in the enhanced sheath field at the target rear.

This new, highly relativistic plasma regime have stimulated the emergence of a new ideas and advanced diagnostic development for measuring plasma effects not even thought today. We will discuss the comprehensive on-line diagnostic systems allowing an extensive and thorough research of laser-plasma processes, providing essential information on their complex dynamics.

This presentation is closely related to recent development or imminently anticipated development of laser technology to bring the existing laser systems to a multi-PW level. Recent findings pave a way to achieving an ion source and beam desire parameters and they encourage further activities for optimisation of laser plasma-based accelerators.