Coherent proton acceleration from isolated micro-plasmas

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We present a unique target system to position micrometer sized targets freely levitating in the focus of a PW laser. The system is based on an electrodynamic trap [1], enabling the use of targets of different form and material. First experiments at the Texas-PW laser [2] allowed for studying the transition from Coulomb explosion towards plasma expansion for increasing target diameters. Experiments at the PHELIX PW laser resulted in a coherent proton acceleration with a narrow energy spectrum around 30 MeV [3]. The novel acceleration mechanism is based on a plasma density slightly below the critical density and features a very good reproducibilty. The density is reduced due to pre-expansion in the rising edge of the laser pulse, which at the same time limits the acceleration process that stops long before the main pulse arrival. As a result only a small fraction of the overall laser energy is effectively used for particle acceleration.

Future experimental plans are targeted to shape a fs laser pulse to control the plasma conditions at the main pulse and thus increase the conversion efficiency from laser into particle energy. We plan plasma expansion studies of isolated micro-plasmas at intensities up to 10^{18} W/cm^2 using the ZEUS laser, which also has a separate probe beam path, at the 'Centre for Advanced Laser Applications' (CALA) in Garching. In this scope we are currently atomizing the operation of the target positioning system for a faster trapping process and (sub-minute) target replacement. This is also a necessary requirement for future experiments at higher repetition rate of the 3 PW ATLAS 3000 laser.

References

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