Trapping electrons in a standing wave for ion acceleration and radiation generation

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High-intensity lasers provide pulses with remarkable localization of electromagnetic energy, giving a base for a rapid particle acceleration and radiation generation. In many scenarios, spatial and temporal synchronization of particles with accelerating fields plays a crucial role for efficient energy conversion. For example, especially high efficiency is achieved for acceleration of electrons, which due to their small mass can quickly start to follow the pulse propagation, gaining energy continuously over a large distance via the mechanism of LWFA.

Due to their much higher mass, it is more difficult to synchronize the motion of ions with accelerating fields. Since the accelerating fields are typically provided by the electrons, their localization and relocation can provide a pathway for efficient acceleration of ions. One can achieve this by trapping electrons in the moving node of a standing wave, produced by reflection of a chirped laser pulse from a solid surface [1]. This concept, called Chirped-Standing-Wave Acceleration (CSWA), has opened a new approach for a uniquely controllable acceleration of ions.

Another interesting example of the benefit of trapped electron dynamics in a standing wave concerns the production of collimated gamma ray beams from electron-positron cascades. These are expected to be triggered at the next generation of multi-PW laser facilities. Producing a large number of electrons and positrons that can emit high energy photons is favoured by tightly focusing and colliding several laser pulses. In this case, the electrons and positrons cannot follow radiation as in LWFA and are expected to be expelled by the laser radiation out of the focal spot. However, the recently discovered phenomenon of anomalous radiative trapping (ART) [2] provides an opportunity to trigger counterintuitive dynamics in the vicinity of the electric field antinodes. These dynamics are especially good for gaining and releasing energy in the form of high-energy photons that are well-collimated along the electric field polarization [3].

In this way, trapping and controlling electrons by a standing wave can be seen as a basic approach for controlling the process of laser-plasma interaction. In my talk I will cover some general aspects of particle trapping in a strong standing wave, and address the latest progress on the above-mentioned concepts.

References

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[3] A. Gonoskov et al. arXiv:1610.06404 (2016).