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Relativistic nanophotonics

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Laser-driven electron acceleration in gas media [1] provides extreme accelerating fields around 100 GV/m, however, using vacuum should offer even multi-TV/m values. These fields are much beyond that of conventional RF devices. Furthermore, the electron bunches have durations in the few-femtosecond regime, which is also much shorter than from conventional facilities.
A novel approach for the acceleration, that we termed relativistic nanophotonics, utilizes solid density nanoplasmas irradiated with sub-5-fs ultra-relativistic laser pulses [2]. The target emits electrons in intensity- and target size-dependent directions. The electrons are in the 5-10 MeV energy range and possess a clear dependence in propagation direction also on the waveform of the laser (carrier-envelope phase). An average experimental accelerating field beyond 1 TV/m is evaluated. Numerical investigations [3] indicate a two-step process behind the interaction. First a nanophotonics step emits electron pulses and accelerates them to a certain energy, while a second vacuum laser acceleration step further accelerates them and determines their final propagation direction. The simulations predict isolated electron pulses with a duration of about 300 attosecond and a peak accelerating field up to 10 TV/m.
These results form the basis of high-energy micro- to nanoaccelerators, record-breaking accelerating electric fields strengths, and isolated attosecond electron bunches. These accelerators are unique candidates as a source of energetic X-ray radiation with attosecond pulse duration.

[1] E. Esarey et al., Rev. Mod. Phys. 81, 1229 (2009).
[2] D. E. Rivas et al., Sci. Rep. 7, 5224 (2017).
[3] L. Di Lucchio et al., Phys. Rev. ST Accel. Beams 18, 023402 (2015).

Working group

Invited plenary talk

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