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Femtosecond few-hundreds-of-keV electron pulses from direct laser acceleration in a low-density gas

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Subrelativistic electrons are a valuable tool for high-resolution atomic and molecular imaging. In particular, electron pulses with energies ranging from 50 to 300 keV have been successfully used in time-resolved ultrafast electron diffraction (UED) experiments to probe physical phenomena on a subpicosecond time scale. Laser-driven electron acceleration has been proposed as an alternative to the static accelerator technology currently in use. In principle, it has several advantages : (i) the short wavelength of the accelerating field may lead to electron bunches with duration of the order of 10 fs or less; (ii) there is an intrinsic synchronization between the electron probe and the laser pump; and (iii) using a gas medium, the electron source is self-regenerating and could be used for UED experiments at high repetition rates. Recently, using three-dimensional particle-in-cell simulations, we showed that 240-keV electron pulses with 1-fs initial duration and 5% energy spread could be produced by radially polarized laser pulses focused in a low-density hydrogen gas [Marceau, et al., Phys. Rev. Lett. 111, 224801 (2013)]. The latest results suggest that 100-500 keV energy with similar duration is within reach of the actual laser technology.

Primary author: Mr MARCEAU, Vincent (Université Laval)

Co-authors: Dr VARIN, Charles (Université d'Ottawa); Prof. PICHÉ, Michel (Université Laval); Prof. BRABEC, Thomas (Université d'Ottawa)

Presenter: Dr VARIN, Charles (Université d'Ottawa)

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