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Temporal characterization of ultrashort electron beams, optically injected and accelerated in a laser-wakefield[1]

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Laser-plasma accelerators, driven by ultraintense and ultrashort laser pulses, sustain accelerating gradients of several hundred giga-volts-per-metre and can deliver high quality electron beams with low energy spread, low emittance and up to giga-electron-volt peak energy. The use of two colliding pulses in a collinear geometry can produce a stable source of electrons that is easily tunable in energy. Here, we report on results of recent experiments with two laser beams colliding with an angle of 135°, thus having the advantage of protecting the laser system from any feedback and facilitating immediate access to the electron beam. For temporal characterization of the electron beam, we measure coherent optical transition radiation in a wide spectral band. Measurements of the absolute number of photons in the mid-infrared spectral band indicate that the electron bunches have durations of only a few femtoseconds. The shape and absolute intensity of the measured CTR spectrum agrees with analytical modeling of electron bunches with durations of 3 to 5 fs [full width at half maximum (fwhm)] and peak currents of 3 to 4 kA, depending on the bunch shape. Under certain conditions, we observe strong oscillations in the visible part of the CTR spectrum. A detailed Fourier analysis reveals that these spectral modulations result from interference of radiation produced by multiple electron bunches. The bunch separation is related to the fringe separation and shifts with plasma density but is always an integer number of plasma wavelengths. It is found that electrons are injected in single- and multiple buckets up to at least ten plasma wave periods behind the first electron bunch.

[1]In collaboration with C. Rechatin, J. Lim, A. Ben-Ismail, X. Davoine, E. Lefebvre, J. Faure and V. Malka.