Synthesis of relativistic quasi-single-cycle light fields and their application in attosecond physics

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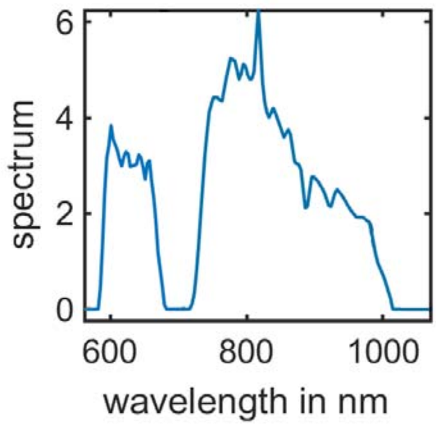
Laser-plasma physics at ultrahigh intensities is normally driven by lasers with few-10 fs or longer pulse duration, while attosecond physics utilizes few-femtosecond sub-TW lasers. Certain applications involving the generation of intense and isolated attosecond x-ray or electron pulses, however, require the combination of the former systems that are not available from lasers. We report on the optical parametric synthesis of quasi-single cycle waveforms that can reach ultra-relativistic intensities up to 10^21 W/cm^2. A pulse duration below 4.5 fs is achieved by amplifying the spectrum between 580 – 1020 nm in two separate spectral regions (see Fig. 1) in two consecutive optical parametric chirped pulse amplifiers. One stage pumped by 355 nm is optimized below 700 nm, while another pumped by 532 nm is optimized above 700 nm. This combination of amplifiers is called optical parametric synthesizer (OPS) [1], which serially synthesizes the spectrum (full spectrum propagates through all amplifiers). Three such OPS double stages provide 440-500 mJ energy in the short light pulse corresponding to 100 TW peak power. Furthermore, the high dynamic range temporal contrast of the system is excellent, which makes it a possible driver in relativistic experiments with nanometric solid targets. Typical applications in attosecond physics will be shortly introduced, such as high-harmonic generation from relativistic laser-plasmas [1,2], high-harmonic generation in gases [1,3], and nonlinear attosecond x-ray interaction [4].



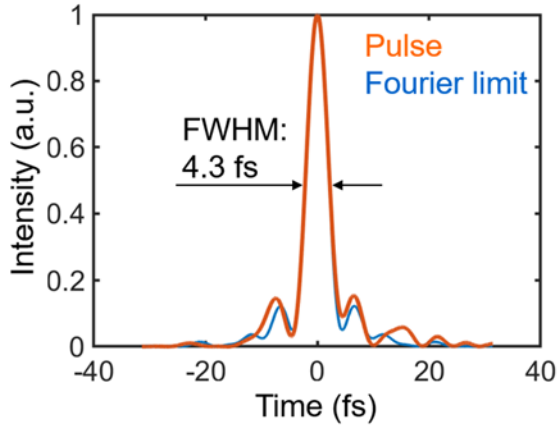


Fig. 1 [left] Spectrum of the Light Wave Sythesizer 100 OPS system, [right] Fourier limit and measured temporal intensity having 4.3 fs FWHM duration.

Literature

[1] D. E. Rivas, et al. "Next Generation Driver for Attosecond and Laser-plasma Physics," Sci. Rep. 7, 5224 (2017).

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