LPAW 2023
Laser and Plasma Accelerators Workshop 2023
lpaw23@tecnico.ulisboa.pt

Monochromatic shadowgraphy and mid-infrared probing of LWFA

Yu Zhao[1], Alexander Sävert[1], Malte C. Kaluza[1]
[1] *1 Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena, Germany*
yu.zhao@uni-jena.de

Ultrafast shadowgraphy with transverse few-cycle probe pulses has enabled the observation of details of the laser-plasma interactions with unprecedented temporal (fs) and spatial (µm) resolution. However, in previous studies, probe pulses spanning a broad frequency spectrum have been commonly used to achieve an acceptable signal-to-noise ratio because of the limit of probe pulse energy [1, 2]. Recently, ultrafast monochromatic shadowgraphic images of laser-generated wakefields became feasible due to an increased probe pulse energy. Narrowband shadowgraphic images are shown in Figure 1, which were taken with a 10 nm (FWHM) bandpass filter at 850 nm center wavelength. The temporal resolution of the shadowgram with the linearly chirped probe pulse is comparable with the Fourier limited few-femtosecond probe pulse. The spectral filtering of shadowgrams can be used to avoid chromatic aberration of the imaging systems and suppress plasma emissions. Furthermore, with a linearly chirped probe pulse, one can potentially achieve a single-shot movie of a plasma wave evolution by spectral filtering [3].

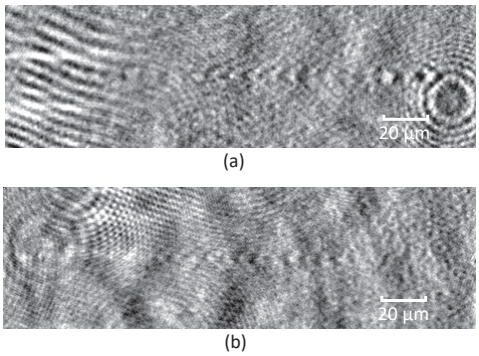

Figure 1: Shadowgrams of plasma waves with a 10 nm (FWHM) bandpass filter at 850 nm center wavelength. Pump pulses propagate from left to right. (a) Fourier transform limited probe pulse with a duration around 8 fs. (b) Linearly chirped probe pulse with a duration around 200 fs.

Nevertheless, in previous pump-probe studies, the probe pulses were split off from the main pulses, which means that the probe spectrum is closely related to the pump spectrum, particularly its central wavelength. This sets a low-density limit ($> 5 \times 10^{18}$ cm^{-3}) for the investigation of LWFAs. In the future, a separate 1 kHz Ti: sapphire laser will be synchronized to the pump laser to generate the probe pulses, with a relative timing jitter of < 20 fs (RMS). With the help of nonlinear optics processes, the central wavelength of the probe pulses can be tuned into the mid-infrared regime, which will allow the direct observation of LWFAs in the low-density regime.

References

[1] M. B. Schwab et al., Appl. Phys. Lett. **103**, 19118 (2013)
[2] A. Sävert et al., Phys. Rev. Lett. **115**, 055002 (2015)
[3] E. Siminos et al., Plasma Phys. Controlled Fusion 58 (2016)