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Characterization of spatiotemporal couplings with far-field beamlet cross-correlation

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For more than three decades, the use of chirped pulse amplification has opened the frontier of high-energy, ultra-short laser pulses. These lasers are exploited as a powerful tool in many fields, particularly in studying laser-matter interaction in the relativistic regime. The broad spectrum and large beam size before focusing on the target make these lasers susceptible to chromatic aberrations known as spatiotemporal couplings (STCs). In most cases, any STCs are undesirable because they increase pulse duration and reduce peak intensity and contrast at the focus. However, in some cases, one can exploit spatiotemporal couplings in a controlled way to manipulate the dynamics of the intense pulses to extend the limits of laser-driven particle accelerators.

We present a novel, straightforward method for the characterization of spatiotemporal couplings (STC) in ultra-short laser pulses. The method employs far-field interferometry and inverse Fourier transform spectroscopy [1]. It stands out in its simplicity: it requires few non-standard optical elements and simple analysis algorithms. This method was used to measure the space-time intensity of the 100 TW class laser at the Weizmann Institute of Science and to test the efficacy of a refractive doublet as a suppressor of pulse front curvature. The measured spatiotemporal couplings agreed with ray-tracing simulations.

In addition, we demonstrate a simpler few-shot measurement technique [2] derived from our primary method, which allows for estimating the low-order STC quickly. We tested the latter technique experimentally on *Salle Noire's* few-cycle laser.

References

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