TW lasers in air: ultra-high powers and optimal control strategies

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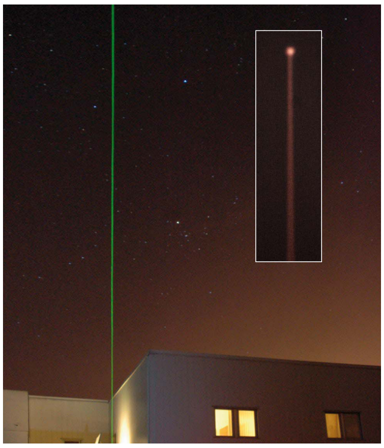

Filamentation, which arises in the propagation of ultrashort laser pulses when the defocusing on the generated plasma dynamically balances the Kerr self-focusing, is now well described on both the laboratory scale (millijoules to tens of millijoules, meters to tens of meters) and the atmospheric scale (hundreds of millijoules, hundreds of meters to kilometers). The scalability of this propagation regime to higher energies and powers is not *a priori* assured, as high-order nonlinear effects may prevent long distance propagation leading, for instance, to full beam collapse. We thus investigated the atmospheric propagation of the 26 J, 32 TW laser pulses delivered by the Alisé beamline, which exceed respectively by one and two orders of magnitude the characteristic power and energy of ultrashort pulses studied so far. We show that filamentation still occurs at these extreme levels. More than 400 filaments simultaneously generate a supercontinuum propagating up to the stratosphere, beyond 20 km. This constitutes the highest power "white-light laser" to date.

We will successively discuss the results of another experiment realized with the Teramobile laser facility[1]: we demonstrated optimal control on the propagation of ultrashort 5 TW laser pulses in air over distances up to 36 m in a closed-loop scheme.[2] We optimized three spectral ranges within the white-light continuum, as well as the ionization efficiency. Optimization results in signal enhancements by typical factors of 2 and 1.4 for the target parameters. In the case of white-light continuum generation, the feedback-driven procedure leads to shorter pulses by reducing their chirp, while, as far as air ionization is concerned, the optimization consists in correcting the pulse from its defects and setting the filamentation onset near the detector.

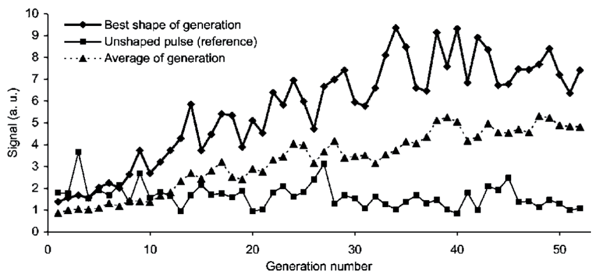

FIG. 1: Optimization of the white-light continuum, in the 355-365 nm spectral region.

[1] Science **301**, 61 (2003).

[2] Applied Physics Letters **89**, 171117 (2006).