Sub-picosecond UV laser pulse filamentation in atmosphere

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Abstract: Filamentation of sub-picosecond UV-laser pulses (248nm, 450fs) with only mJ energy propagating in atmosphere is reported. Spectral broadening, pulse compression and a uniform plasma channel formation are the main attributes of this nonlinear propagation mode.

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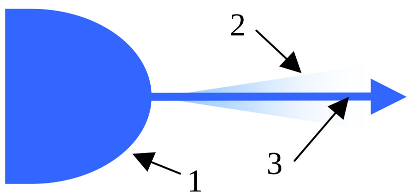
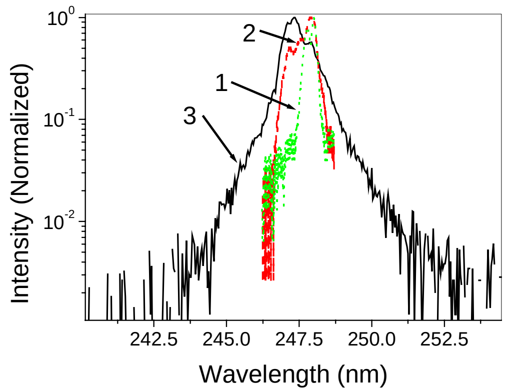
Several studies have shown recently that ultrashort infrared laser pulses propagating through atmosphere may create long plasma filaments [1]. This effect may have important applications in laser-controlled discharges, long-range deposition of high laser intensities, new LIDAR monitoring, etc [2]. Here we present an investigation of the nonlinear propagation of sub-picosecond UV laser pulses in air. We show, for the first time, that filamentation is possible with UV laser pulses as well.

The 248 nm laser pulses used, have maximum energy of 8 mJ and duration of 450 fs. They are obtained by an Excimer pumped femtosecond dye laser. The pulses were launched through atmosphere in a converging beam geometry. At high intensities, an important displacement of the focus towards the lens was observed. About 10% of the initial beam energy propagated beyond the focus in the form of a narrow beam of constant diameter of about 200 µm, 50% of the beam energy was lost in the focal region, and 40% was contained in a diverging conical beam surrounding the filament.

The spectrum of the ring that surrounds the filament experiences small broadening, towards higher energies. By contrast the spectrum of the filament itself is significantly broadened as shown in the figure. Moreover, measurements of the pulse duration, in the filament, by interferometry indicate an important reshaping and shortening.





Left: schematic representation of the pulse spatial profile. 1) beam before onset of filamentation, 2) conical beam, 3) filament. Right: spectrum of the pulse in the three corresponding regions. The input pulse energy is 1.7 mJ.

The spectrum of the filament is globally shifted towards higher energies, evidence of ionization. Indeed air conductivity measurements in the filament confirm the presence of a plasma channel extending over several meters.

Numerical simulations of the UV laser beam propagation using a 3-Dimensional code with axial symmetry were performed. The code considers beam self-focusing due to the optical Kerr effect, beam defocusing due to multiphoton ionization of air molecules and normal beam diffraction. The outcome of those simulations for initial conditions close to the experimental ones validate the above results

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[2] X. M. Zhao *et al.*, IEEE J. Quantum Electron. **31**, 599 (1995); L. Wöste *et al.*, Laser Optoelektron **5**, 29 (1997).