Characterization and optimization of infrared emission from light filaments observed in a fs-TW laser beam propagating in the atmosphere

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Very high peak power and ultrashort pulse duration result in various nonlinear effects when fs-TW laser pulses propagate through air. In addition to linear diffraction, self-focusing as well as local plasma-induced defocusing has to be taken into account. Self-guided filaments can take place when a dynamic balance between the above mechanism is established. Such filaments remain confined for distances much longer than the Rayleigh length, reaching several tens of meters under well chosen circumstances. The spatial confinement in the filaments provides a long interaction path, which enhances the nonlinear frequency conversion processes by self phase modulation, stimulated Raman scattering and four-wave-mixing. The spectral content of the filaments observed in a 2-TW laser beam propagating in atmospheric-pressure rare gases has been investigated in the visible and the UV ranges [1]. A so-called hypercontinuum has been measured from 150 nm to 900 nm.

More recently, long-range white light experiments in the VIS were conducted that revealed the potential of a pulsed white light source for atmospheric measurements [2]. In order to extend these measurements in the NIR, optimization of the infrared emission is a necessary prerequisite. Despite of the difficulties in performing measurement, we have detected infrared emission up to 4.5 µm from light filaments. The extremely broadband continuum would allow simultaneous multi-spectral measurements. This is especially interesting in the infrared where high energy tunable laser pulses are difficult to produce and where a number of pollutant gases (VOC's) have high absorption bands.

In this paper, we present our results on the characterization and the optimization of the infrared component of the continuum emitted from light filaments. Infrared emission efficiency is studied as a function of several laser parameters, such as pulse energy, duration, and frequency chirp. For LIDAR application purposes, different beam transmission configurations are studied. The fundamental beam can be sent in the atmosphere either collimated in parallel beam or slightly focused. White light can be also re-collimated. Infrared intensities at remote distances are optimized.

References

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Infrared emission from light filaments observed in a fs-TW laser beam propagating in the atmosphere has been measured up to 4.5 µm. Its intensity has been optimized by the variation of laser pulse characteristics and the beam propagation geometry.