Spatiotemporal Control of Laser Filaments for Atmospheric Applications

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Laser filamentation is a nonlinear phenomenon observed during the propagation of femtosecond laser pulses with GW-peak-power in air. It results in the self-contraction of the beam, maintaining a very high intensity in a thin channel with an almost constant radius over many Rayleigh lengths, and leaving a plasma channel in the wake of the laser pulse. This spectacular effect, which can be obtained at a long distances, could be very useful for numerous remote applications requiring high laser intensity, such as the laser lightning rod [1], for laser telecommunication through fog [2,3].

In this talk I will review recent experiments performed at LOA, where structured beams have been used to organize multiple filamentation [4,5], and where the cumulative effect appearing at kHz repetition rate has been utilized to enhance the aerodynamic effects of the filament [4]. We demonstrated the generation of a permanent air waveguide over 20 meters using a high power kHz Yb:YAG laser.

In the second experiment we used the flying focus technique to control the velocity and direction of the ionization front in the filament. We then demonstrate that an ultrashort optical pulse generating a short plasma filament in air can emit THz radiation in any direction with respect to its propagation axis. The emission angle can be tuned by changing the input chirp of the laser pulse [6].

References

[1] A Houard, P Walch, T Produit, *et al.*, Nat. Photonics **17**, 231 (2023)

[2] N Jhajj, E W Rosenthal, R Birnbaum, *et al.*, Phys. Rev. X **4**, 011027 (2014)

[3] G Schimmel, T Produit, D Mongin, *et al.*, Optica **5**, 1338 (2018)

[4] S Fu, B Mahieu, A Mysyrowicz and A Houard, Opt. Lett. **47**, 5228 (2022)

[5] S Fu, A Mysyrowicz, L Arantchouk, M Lozano and A Houard, Appl. Phys. Lett. **125**, 011103 (2024)

[6] S Fu, B Groussin, Y Liu, A Mysyrowicz, V Tikhonchuk and A Houard, Phys. Rev. Lett. **134**, 045001 (2025)