Meter-scale streamer discharges assisted by femtosecond laser filamentation

Thomas Clark, Quentin Gutierrez, Leonid Arantchouk, Magali Lozano, and Aurelien Houard

Laboratoire d'Optique Appliquée, ENSTA, Ecole Polytechnique, CNRS, Institut Polytechnique de Paris, 828 Boulevard des Maréchaux, 91762 Palaiseau Cedex, France
Email: Thomas.clark@ensta.fr

The advent of intense ultrashort laser systems (P > 5 GW, τ < 1 ps) has demonstrated their ability to generate weakly ionized plasma columns in the atmosphere [1]. Known as femtosecond laser filamentation, this phenomenon has provided new tools for the control of high-voltage (HV) discharges. Laser filamentation has been actively investigated for triggering HV devices [2–4], generating plasma antennas [5], and controlling lightning [6, 7].

We used filaments induced by a femtosecond terawatt laser to control the propagation of a streamer discharge in air, over a distance of 1 m. This process gives rise to laser-guided spark discharges characterized by a straight geometry. A triggered Tesla voltage generator delivering voltage pulses up to 300 kV is used to produce the spark.

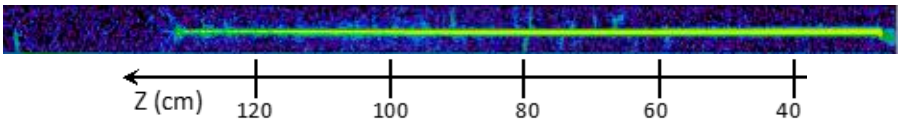

Figure 1: *Fast camera image of a meter scale guided discharge*

Using a fast camera and electric diagnostics we studied the development of the laser-guided discharges. We found that the presence of the filament modifies the characteristics of the streamers, a feature that remains poorly understood.

To investigate this guided streamer phase, we employed a drift–diffusion code called Chombo-Discharge [10] simulating the collisional front of the streamer in the presence of a laser filament. Preliminary results are presented here.

References

1. A. Couairon and A. Mysyrowicz, Phys. Rep. **441**, 47 (2007).
2. H. Pépin, et al., Phys. Plasmas **8**, 2532 (2001).
3. M. Rodriguez, et al., Opt. Lett. **27**, 772 (2002)
4. L. Arantchouk, et al., Appl. Phys. Letters **104**, 103506 (2014).
5. Y. Brelet, et al. Applied Physics Letters **101** (26), pp.264106 (2012).
6. J.-C. Diels, et al. Sci. Am. **277**, 50–55 (1997).
7. A. Houard, et al. Nat. Photon. **17**, 231–235 (2023).
8. R. Marskar, Journal of Open-Source Software, **8**(85), 5335 (2023).