Picosecond laser filamentation in air
Andreas Schmitt-Sody, Heiko Kurz, L Bergé, Stefan Skupin, Pavel Polynkin

To cite this version:
Andreas Schmitt-Sody, Heiko Kurz, L Bergé, Stefan Skupin, Pavel Polynkin. Picosecond laser filamentation in air. European Quantum Electronics Conference, Jun 2015, Munich, Germany. pp.EE_P_1. hal-01205539

HAL Id: hal-01205539
https://hal.science/hal-01205539
Submitted on 25 Sep 2015

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Picosecond laser filamentation in air

Andreas Schmitt-Sody1, Heiko G. Kurz2, Luc Bergé3, Stefan Skupin4, and Pavel Polynkin5

1. Air Force Research Laboratory, Albuquerque, New Mexico, USA
2. Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany
3. CEA, DAM, DIF, 91297, Arpajon, France
4. Univ. Bordeaux - CNRS - CEA, Centre Lasers Intenses et Application, UMR 5107,33405 Talence, France
5. College of Optical Sciences, University of Arizona, Tucson, Arizona, USA

Email: ppolynkin@optics.arizona.edu

Laser-generated plasmas in air have potential utility in diverse application areas ranging from the guidance of electrical discharges to remote sensing. Ionization of air and other gases by powerful laser pulses has been intensely investigated in the femtosecond [1,2] and nanosecond [3] regimes. However, plasma channels produced through fs excitation are dilute and short-lived, while plasmas generated through nanosecond optical breakdown are typically fragmented into disconnected plasma bubbles. Both shortcomings severely limit practical applications. Attempts to combine femtosecond and nanosecond laser excitations in the so-called igniter-heater scheme [4] do result in the production of extended and dense plasma channels, but, like in the case of pure nanosecond excitation, the generated plasma channels are fragmented into discrete bubbles.

In this contribution, we explore, both experimentally and numerically, an under-investigated regime of air ionization by intense near-infrared laser pulses with duration in the picosecond range. Earlier experiments have shown that in this regime the generated plasma channels can be both dense and continuous [5]. Here we use weakly focused laser pulses at 1,053 nm wavelength, with pulse durations variable from 0.5 to 10 picoseconds, and with the laser-pulse energies of up to 10 Joules. We show that plasma channels generated in air by such pulses are approximately uniform, both longitudinally and transversely. By examining the burn patterns produced on a glass surface by the intense laser beam in the filamentation zone we show that the phenomenon of intensity clamping that has been originally demonstrated for the case of femtosecond laser filaments [6], holds in the picosecond regime. The value of the fluence steadily grows as the pulse duration increases, as shown in Fig. 1(B). Numerical simulations reveal that an intense, clamped spike develops on propagation, on the leading temporal edge of the pulse. The generated plasma densities are of the order of $10^{18}$/cm$^3$, significantly higher than that in femtosecond laser filaments, which is a direct consequence of the longer pulse durations. Our results suggest that picosecond laser filamentation in air may have the advantages of both femtosecond and nanosecond plasma excitations, without the drawbacks associated with either of the two regimes.

This work was supported by the US Air Force Office of Scientific Research under programs FA9550-12-1-0143 and FA9550-12-1-0482 and by the US Defence Threat Reduction Agency under program HDTRA 1-14-1-0009. The use of the Jupiter Laser Facility was supported by the US Department of Energy, Lawrence Livermore National Laboratory, under Contract No. DE-AC52-07NA27344.

References
[1] A. Couairon, A. Mysyrowicz, “Femtosecond filamentation in transparent media”, Phys. Rep. 441, 47 (2007).
[2] L. Bergé, S. Skupin, R. Nuter, J. Kasparian, J.-P. Wolf, “Ultrashort filaments of light in weakly ionized, optically transparent media”, Rep. Prog. Phys. 70, 1633 (2007).
[3] Principles of laser plasmas, G. B. Beken. (Wiley, New York, 1976).
[4] P. Polynkin, J. Moloney, “Optical breakdown triggered by femtosecond laser filaments”, Appl. Phys. Lett. 99, 151103 (2011).
[5] D. Kartashov, S. Alisauskas, A. Baltuska, A. Schmitt-Sody, P. Roach, P. Polynkin, “Remotely pumped stimulated emission at 337 nm in atmospheric nitrogen”, Phys. Rev. A 88, 041805(R) (2013).
[6] S. Xu, J. Bernhardt, M. Sharifi, W. Liu, S. L. Chin, “Intensity clamping during laser filamentation in air and argon”, Las. Phys. 22, 195 (2012).