Plasma optics: ion gratings for energy transfer in the picosecond regime

L. Lancia[1], J.-R. Marquès[1], F. Amiranoff[1], R.L. Berger[2], M. Blecher[3], S. Bolaños[1], M. Chiaramello[4], J. Fuchs[1], T. Gangolf[1,3], A. Giribono[5], K. Glize[6], C. Riconda[4], S. Weber[7], O. Willi[3]

[1] *LULI, CNRS, École Polytechnique, CEA, Sorbonne Université, Palaiseau, France*

[2] *Lawrence Livermore National Laboratory, Livermore, California 94550, USA*

[3] *ILPP, Heinrich-Heine Universität Düsseldorf, 40225 Düsseldorf, Germany*

[4] *LULI, Sorbonne Université, CNRS, École Polytechnique, CEA, Paris, France*

[5] *Dip. SBAI, Università di Roma "La Sapienza", Via A. Scarpa 14, 00161 Rome, Italy*

[6] *CEA, DAM, DIF, F-91297 Arpajon, France*

[7] *Institute of Physics of the ASCR, ELI-Beamlines, 18221 Prague, Czech Republic.*

At the interface between laser-plasma physics and photonics "Plasma optics" aims at manipulating high intensity laser pulses by exploiting the optical properties of a plasma. Transient plasma structures (or plasma photonic crystals, or gratings) present a ultrahigh damage threshold that overcomes the limit of traditional solid-state optics and makes it possible to manipulate and control ultra-short intense laser pulses[1].

Two kinds of gratings can be produced in a plasma by the beating of two transverse electromagnetic waves (laser beams). According to the nature of the particle motion, whether electron (Raman) or ion (Brillouin) plasma waves, the properties of these structures differ in terms of lifetime and light manipulation capabilities.

The possibility to generate ion plasma gratings and induce a controlled energy transfer is by now well established [2]. At laser intensities as high as $10^{15}-10^{16}$ W.cm^{-2} the characteristic time-scales for the setup of these non-linear ion-like waves can easily attain a few hundred femtoseconds and their lifetime can last several picoseconds.

We will review the progress in the realization and optimization of an ion grating (Stimulated Brillouin Scattering) based amplifier, discuss the main limits that affect the energy transfer. We will present recent results in the case of counter-propagating as well as co-propagating, sub-picosecond beams at the same wavelength. We will discuss the role of laser and plasma parameters in the interaction geometries.

References

[1] P. Michel *et al.*, Phys. Rev. Lett. **113**, 205001 (2014); D.Turnbull *et al.*, Phys. Rev. Lett. **116**, 205001 (2016); G. Lehmann et al., Phys. Rev. Lett. **116**, 225002 (2016);

[2] L. Lancia et al., Phys. Rev. Lett. **104**, 025001 (2010); **116**, 075001 (2016); M. Chiaramello, *et al.*, Phys. Plasmas **23**, 072103 (2016).