

Hydrodynamic and Maxwell-Bloch modelling of plasma-based soft X-ray amplifiers.

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Recently, sub-picosecond pulses of High Order Harmonics (HOH) amplified in a dense plasma have been demonstrated [1]. In order to pump the amplifier, it is necessary to propagate an intense infrared (IR) laser through several millimetres of dense plasma. Deleterious effects, as overionization induced refraction, may appear hindering the propagation of the IR beam. A preformed plasma channel helps overcoming these effects [2]. However, critical parameters like the maximum propagation length of the IR beam, the maximum electron density at the centre of the channel and the degree of ionization vary in a fast timescale. In order to optimize the amplification scheme (i.e. Optimum pump time, optimum seeding time, etc ...) we have modelled the creation of the plasma channel with the 2D hydrodynamic code ARWEN [3]. The evolution of the plasma channel as given by the code can be compared with experimental results.

In addition to this, we have performed Maxwell-Bloch simulations of the amplification of seeded HOH in the previous amplifiers [1] and atmospheric nitrogen amplifiers [4]. The amplification curves as given by our code present an excellent match with experimental results (figure 1.) allowing us to diagnose plasma parameters as the collision frequency.

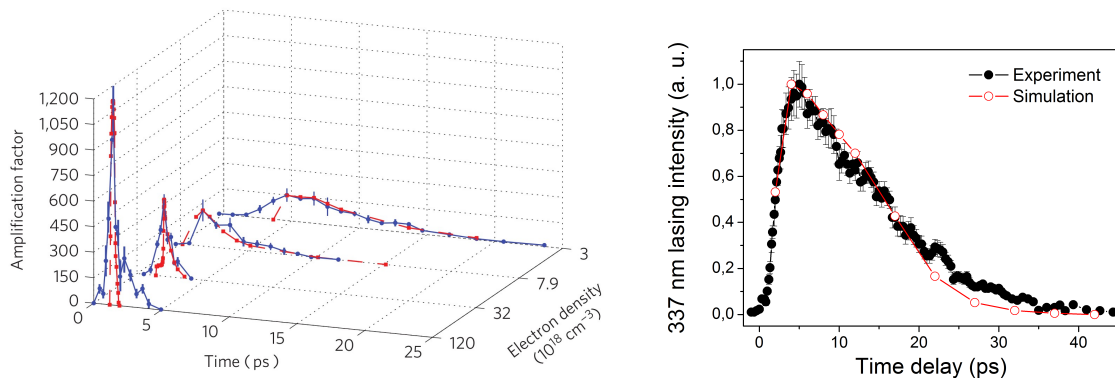


Figure 1: Experimental and modeled amplification curves of a Ni-like Kr plasma amplifier (left, from [1]) and an atmospheric nitrogen amplifier (right).

[1] A. Depresseux, et al, Nature Photonics, 9, 817-821 (2015)

[2] E. Oliva, et al, Phys. Rev. A, 92, 023848 (2015)

[3] E. Oliva, et al, Phys. Rev. E, 82, 056408 (2010)

[4] P. Ding, et al, Opt. Express, 22, 29964-29977 (2014)