2D – 3D multiscale modelling of inhomogeneous plasma amplifiers

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In a recent experiment [1] a plasma waveguide was created in Kr gas to allow the propagation of an intense IR pump pulse and create an OFI Kr^{8+} amplifier. When seeded with HOH, the resulting XUV beam attained sub-picosecond duration. Moreover, the intensity and phase profile of the amplified beam present complex structures, a hint of the inhomogeneous nature of the amplifier. The full modelling of this kind of amplifier involves multiple spatio-temporal scales, from those of plasma hydrodynamics (ns, mm), propagation of IR pulses through millimetres of plasma (ps, mm) and electron-ion collisions (ps) to the ones related to the propagation (ps, mm) and amplification (fs) of the HOH seed.

We will present the application of this multiscale modelling paradigm to explain recent experimental results [2] in which the intensity and phase profile of the HOH was characterized. We will show that the observed structures are a signature of the inhomogeneous electron and ion densities. Consequently, the amplified beam acts as a probe capable of unveiling the presence of under and overionized regions (i.e. regions where ions with ionization states lower/greater than that of the lasing ion) in different regions of the amplifier.

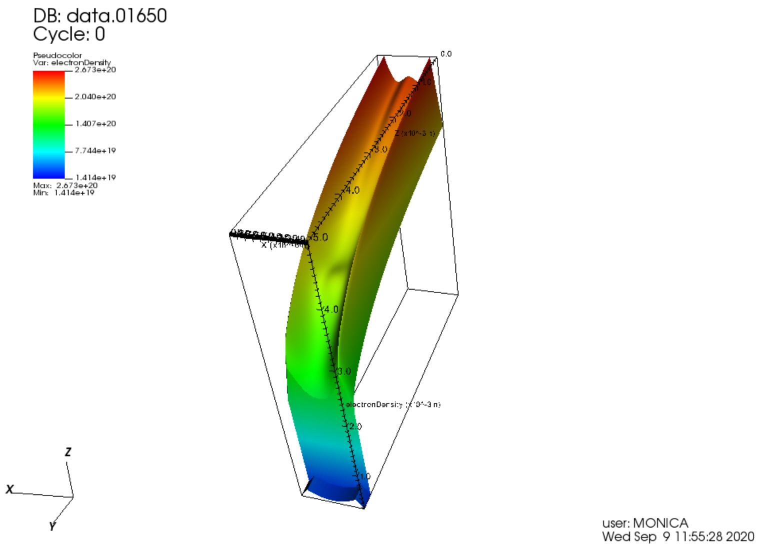

Figure 1: Electron density profile of the plasma waveguide as given by our multiscale modelling. The IR pump and HOH seed propagate in the up-down direction.

[1] A. Depresseux, *et al*, *Nature Photonics*, **2015**, *9 (12)*, 817-821.
[2] F. Tuitje, *et al, Light : Science & Applications,* **2020**, accepted for publication.