Can we shorten the pulse duration of plasma-based soft x-ray lasers below 1 ps ?

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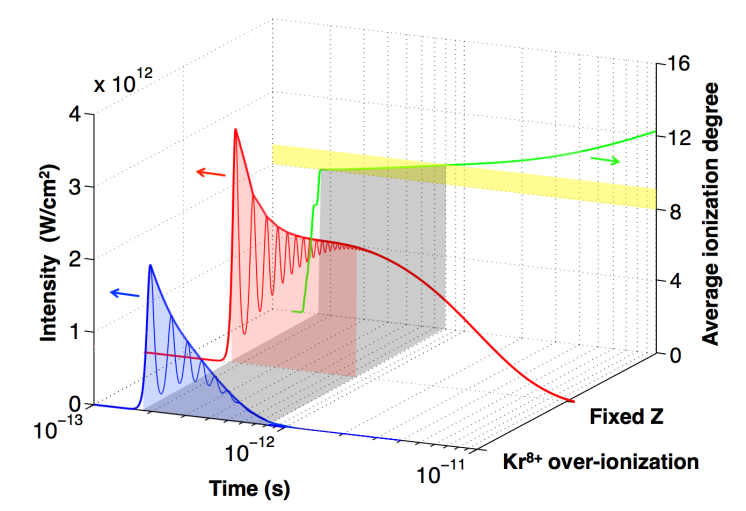
In plasma-based soft x-ray laser systems, the amplifier lifetime strongly depends on the depletion rate of the lasing-ion population because of collisional ionization during the lasing process. In 2015, we proposed and demonstrate a novel approach based on the gating of the gain media to reduce the time window in which the lasing action takes place. By increasing the density of the plasma-amplifier, this process becomes fast enough to provoke an anticipated interruption of the amplification process and consequently shortens the duration of the soft XRL pulse.



In our work, an ultrashort infrared laser pulse was focused onto a krypton-gas jet to generate the lasing-ion species through optical-field ionization. The resulting electron distribution permits a population inversion by collisional pumping that leads to the lasing of the $3d^9 4d_{J=0} \rightarrow 3d^9 4p_{J=1}$ transition of nickel-like krypton at 32.8 nm.

The figure brings into comparison the amplified HH pulses in the real case, when the plasma ionization degree progressively increases through collisional ionization (blue curve) and in case of an artificially blocked ionization degree (red curve). Those temporal pulse profiles are confronted to the evolution of the average ionization degree of the plasma amplifier over time (data from OFI-0D atomic code). The yellow-tinted are show the region where Kr^{8+} lasing ions exist. This region defines a time window (grey-tinted area), in which lasing action occurs (blue curve). When overionization of the lasing ions population is blocked, the SXRL pulse duration is substantially longer (1.15 ps FWHM compared to 123 fs FWHM for the blue curve).

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