Solid target seeded soft x-ray laser for short pulses and orbital angular momentum beams amplification

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Harmonic seeded operation of plasma-based soft x-ray laser has been an important step for this field of research [1]. It has been shown that some properties of the high-order harmonic seed can be transferred to the amplified beam: the soft x-ray laser inherits the spatial coherence and the polarization of the seed [2]. However, the harmonic pulse duration is strongly stretched due to the orders of magnitude spectral bandwidth difference between the seed and the amplifier [3]. Recovering as much of the original pulse duration is a subject of active research. Furthermore, it is now possible to investigate the conservation of other degrees of freedom of the incoming seed, such as its Orbital Angular Momentum (OAM).

In this paper, we will first describe the successful ASE and seeded operation of a soft x-ray laser pumped with a pumping pulse incident with a grazing angle of Φ=32° [3]. This configuration is expected to double the electron density in the lasing region compared to the standard configuration (Φ=22°). The ASE laser pulse is observed to stay in the microjoule range. The seeded operation was achieved by tuning the seed injection angle, to mitigate partially the strong refraction in the plasma density gradient. Temporal coherence measurement of the ASE emission and injection delay investigation give evidence of a bandwidth two times higher for this configuration (Φ=32°) compared to the standard one (Φ=22°), consistent with a two-times increase in electron density in the lasing region. Using these observations to constrain 1D Bloch-Maxwell simulations, a pulse duration of 500fs is predicted for the seeded high-density configuration.

In the second part, we will present the results of a soft x-ray laser seeding experiment with harmonic beams carrying OAM with a topological charge of l=±25 and l=±50. The amplification of a part of the beam has been recently achieved. We will conclude by describing the effort remaining to amplify a complete beam.

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