X-ray Laser Developments at PHELIX

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Introduction

We report on results of a double-stage molybdenum x-ray laser experiment. The two targets were pumped using the double-pulse grazing incidence pumping technique, which includes travelling wave excitation for both the seed- and the amplifier-target..

The main motivation for X-ray laser (XRL) research at GSI is to perform spectroscopy experiments on highly-charged heavy-ions stored in the experimental storage ring (ESR) of the GSI accelerator facility[1]. The first experiment of this kind will aim at measuring the 2s1/2 – 2p1/2 transition in Li-like ions. For ions of an atomic number between 50 (Sn) and 92 (Ur), this transition energy lies between 100 eV and 300 eV [1], which corresponds to wavelengths between 12 nm and 4 nm. Setting up the experiment in a way, where the XRL is counter propagating to the ion bunch, one can exploit the relativistic Doppler effect. The use of laser-pumped plasma XRL's, with typical photon energy up to 100 eV [2,3,3] can address the whole range of lithium-like ions for the lowest lying transitions The perspective for FAIR, given by the even higher ion velocities at HESR , opens a completely new range of experiments.

Experiment

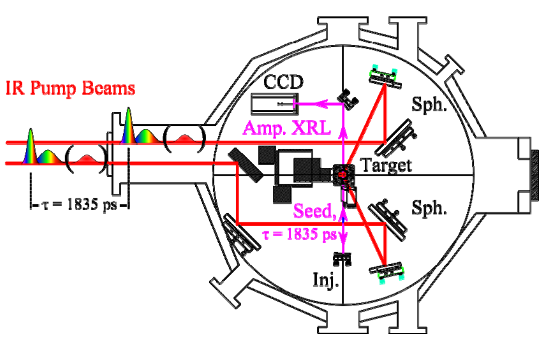

Fig. 1. Sketch of the experimental setup. A more detailed description is given in the text.

A Mach-Zehnder like interferometer, which was implemented in the short-pulse frontend of the PHELIX laser, was used to create the chirped double-pulse structure required for the DGRIP scheme [2]. After compression, the pulse duration of the two pulses was 200 ps (prepulse) and 2 ps (main pulse). Using the PHELIX preamplifier section, the total pump energy on the target amounted to 600 mJ, equally distributed between two individual pumping beams. Inside the target chamber, the two beams were focused in opposite direction onto the Mo slab target by two spherical mirrors, as illustrated in Fig. 1. The line foci were vertically separated by ~ 3 mm. The output of the lower XRL – the seed pulse - was focused into the upper – amplifying- medium by a spherical XUV mirror.

Results

Seeded x-ray laser operation has been demonstrated, resulting in x-ray laser pulses of up to 240 nJ and 2 mrad × 2 mrad divergence. The peak brilliance of the amplified x-ray laser of 4×10^{23} photons /s /mm² /mrad² in 5×10^{-5} relative bandwidth was more than two orders of magnitude larger compared to the original seed pulses.Figure 1 shows the typical beam patterns of the HH observed (filters: Zr and Ti) under (a) only He gas jet (valve stagnation pressure: 4000 mbar), (b) Ne 400 mbar jet, and (c) both gas jets for Ne 400-He 4000 mbar.

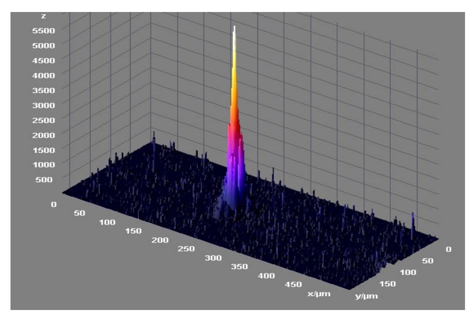

Fig. 2: Beam quality of the seeded XRL. showing 2 mrad × 2 mrad divergence.

References

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