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Increasing X-Ray Photon Energies by Super Thermal Electrons From Two-Plasmon Decay

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This year, the experimental site of GSI's SIS heavy ion synchrotron will offer the unique combination of high-energy heavy-ion beams and ns-pulses of the PHELIX laser with energies up to 200 J. Pulses of heavy ions with up to $2 \cdot 10^9$ particles in a short bunch of 100 ns will allow to isochorically heat mesoscopic samples to extreme conditions, reaching the Warm Dense Matter (WDM) regime at near equilibrium conditions. In order to diagnose these samples, a high-brilliance source of highly penetrating radiation is necessary to overcome the background radiation created by the ion beam itself. The brilliance of laser-driven X-ray sources, when coupled to advanced X-ray-based measurement methods, is very attractive for such an application. While the conversion efficiency of laser radiation into X-ray line emission has been studied extensively worldwide, its optimization could increase the brilliance of the secondary source and in turns be beneficial for our application.

This work will focus on the optimization of laser induced X-ray line emission which is crucial for some diagnostic methods such as X-ray diffraction. The main objectives are high photon energies, i.e. producing line emission in high-Z targets, and high photon numbers. Enhancing these two quantities allows to apply the diagnostics to WDM samples with larger thicknesses and densities.

High photon energies are a special challenge because the PHELIX ns-pulse intensity is limited to a few times 10^{15} W/cm^2 corresponding to maximum electron temperatures of $3-4$ keV. We therefore investigated the possibility to exploit the process of two-plasmon decay (TPD) for producing super thermal electrons resulting in more X-ray photons. While in Inertial Confinement Fusion (ICF) Experiments [1] TPD has to be mitigated to avoid preheat of the target, here our aim was to identify a regime accessible with the available PHELIX parameters where TPD is enhanced as much as possible. For this purpose, we used metallic targets with a low-Z plastic coating to extend the plasma density scale length around quarter critical density, where TPD occurs, in order to increase the number of superthermal electrons produced by TPD. We will report on the findings of our recent PHELIX experimental campaign and discuss the implications for the ns-pulse driven X-ray sources as diagnostic tools for WDM-studies.

References

[1] D. H. Froula *et al.*, 'Saturation of the Two-Plasmon Decay Instability in Long-Scale-Length Plasmas Relevant to Direct-Drive Inertial Confinement Fusion', *PRL,* 2012.

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