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Study of Kα X-ray source size based on high-intensity femtosecond laser-solid interaction

Mathieu Gambari[1], **Olivier Peyrusse[1]**

[1] *Aix-Marseille Université, CNRS, Laboratoire LP3, Marseille, France*

Table-top plasma X-ray sources driven by high-peak power (fs) laser sources are of high applicative interest for imaging and material science [1,2] because of their capability to provide hard energetic, jitter-free point-source pulsed X-ray sources suitable for phase-contrast imaging or (time-resolved) X-ray diffraction. We thus study the characteristics (mainly here focusing on its size evolution) of a hard Kα Mo X-ray source ($E_{K\alpha} = 17.48$ keV) produced by a high intensity femtosecond laser interacting with a solid molybdenum target for a wide range of laser intensity (I $\sim 1 \times 10^{17} - 2.8 \times 10^{19}$ W/cm^2) and for four values of the temporal Contrast Ratio ($6.7 \times 10^7 <$ CR $< 3.3 \times 10^{10}$). The temporal contrast ratio was varied by inserting or removing saturable absorbers between the different preamplifier stages of the laser chain [3]. Results demonstrate that increasing the laser intensity leads to enlargement of the X-ray source size and this phenomenon is emphasized when the temporal contrast of the laser driving pulse is deteriorated [4]. To explain these observations, we developed dedicated experiments and hydrodynamic simulations to estimate the impact of laser absorption mechanisms and hot electron scattering inside the solid on the evolution of both the X-ray source size and the Kα photon number. However, while bringing light on Kα photon number changes, they do not explain the increase of the X-ray source size. We finally deduce that the most probable mechanism leading to the broadening of the source size is linked to the creation of surface electromagnetic fields which confine the hot electrons at the solid surface [5]. This assumption is supported by experiments made with the highest contrast ratio and in which the evolution of the size enlargement of the X-ray source is studied as a function of the laser focal spot size.

References

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Presenting Author Email Address: *olivier.peyrusse@univ-amu.fr*