



High contrast laser driven intense x-ray source for imaging application

Liming Chen

Laboratory of Optical Physics in Institute of Physics, Chinese Academy of Sciences
P. O. Box 603-33, Beijing 100190, China
E-mail: lmchen@aphy.iphy.ac.cn

Hard x-ray emission from femtosecond laser produced plasmas has been studied in the past years. Such hard x-ray sources have a number of interesting applications in the dynamic probing of matter and in medical imaging. However, the hard x-ray emission produced by high intensity laser-solid interactions relies on hot electrons. It has been shown that using shorter laser pulses, with durations less than 100 fs, a limitation on the hard x-ray emission with increasing laser intensity for tens of fs laser pulse duration when low contrast leads to preplasma formation and to the RA mechanism. And also, typically the x-ray continuum in spectrum is strong and usually contains 90% of total x-ray energy with photon energies > 1 keV [1]. The small energetic x-ray tail will greatly reduce the subject contrast of in-line radiography. This are disadvantages for laser-based x-ray sources in imaging applications.

we show that the limitation on the hard x-ray emission enhancement can be overcome by using high contrast relativistic fs laser pulses. In this regime the “Vacuum Heating” is the main mechanism for the hot electron generation. It does not saturate with the laser intensity and results in enhancement of the x-ray emission. We control and optimize the yield of the x-ray emission via generating positively or negatively modified laser pulses. The Cu η_K reaches a maximum, 4×10^{-4} , for 100 fs negatively modified pulse irradiation.

In order to get more clean x-ray source, we present the result of hard x-ray spectroscopy from an Ar gas + cluster target irradiated by a femtosecond laser pulse at 10^{17} W/cm² [3]. The spectrum shows a high contrast characteristic K-shell emission, a compressed continuum and the elimination of the energetic x-ray tail typically observed with solid target. This Ar K-shell x-ray with very little continuum background possesses the measured flux of 1.2×10^3 photons/mrad²/pulse. The peak brightness is estimated to be $\sim 1.2 \times 10^{21}$ photons/s/mm²/mrad², which is comparable to the third generation synchrotron radiation sources. This compact quasi-monochromatic x-ray source, with a source size of only 12 μ m, has been applied to x-ray radiographic imaging of a biological specimen, resulting in high-resolution phase-contrast images. Recently, tenfold of x-ray enhancement is obtained [4] which ascribe to the new electron heating mechanism. For the first time, single-shot keV photon phase-contrast-imaging is available now which is suit for the ultrafast x-ray radiography. This source is proved to be ultrashort with duration ~ 10 fs. It is open for any topics which require this kind of ultrafast keV x-ray source in imaging and other application.

1. J. Yu *et al*, *Phys. Plasmas* **6**, 1318 (1999)
2. L. M. Chen *et al*, *Phys. Rev. Lett.* 100, 045004(2008)
3. L. M. Chen *et al*, *Appl. Phys. Lett.* 90, 211501(2007)
4. L. M. Chen *et al*, *Phys. Rev. Lett.* 104, 215004(2010)