Enhancement of betatron X/γ-rays in a laser plasma accelerator

Liming CHEN[1,2]*, Yong MA[1], Kai HUANG[1],Wencao YAN[1], Jie ZHANG[1,2]

[1]*Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China*
[2] *Key Laboratory for Laser Plasmas (MOE) and IFSA Collaborative Innovation center, Shanghai Jiao Tong University, Shanghai 200240, China*
** lmchen@iphy.ac.cn*

Hard x-rays from fs laser produced plasmas have a number of interesting applications in the dynamic probing of matter and in medical/biological imaging. Betatron radiation is a highly collimated laser-driven hard x-ray source with fs duration which generated by electron transversely oscillation during acceleration in underdense plasmas. We will summarize our recent progress in enhancing the betatron x-ray sources.

1) A new method is demonstrated for generating intense betatron x-rays using a clustering gas target irradiated with an ultra-high contrast laser of 3 TW only [1]. The yield of the Ar x-ray betatron emission has been measured to be 2×108 photons/pulse. Simulations point to the existence of clustering as a contributor to the DLA mechanism, leading to higher accelerated electron charge (x40) and much larger electron wiggling (~8 μm) amplitudes in the plasma channel, thereby finally enhancing the betatron x-ray photons.

2) Another concept of generation of bright betatron radiation during electron acceleration was newly invented [2]. Two electron bunches with different qualities were injected sequentially into the wakefield driven by a super-intense laser pulse. The first one is a mono-energetic electron bunch with peak energy of GeV level, and the second one is injected continuously with large charge and performs resonantly transverse oscillation with large amplitude during the subsequent acceleration, which results in the enhancement of betatron x-ray emission. After optimize interaction conditions, -rays with yield reaches to 1010 can be obtained by using 200TW laser [3].

3) In order to control the stability of betatron x-ray generation as well as enhance its yield and energy, ionization injection with N2 gas is studied. We obtained stably accelerated monoenergetic electron beams with energy spread 5% for the first time [4]. 109 photons in hard x-rays and 108 photons in -rays are stimulated, results in a peak brightness 1023 phs/s/mm2/mrad2/(0.1%BW). Quick injection, acceleration and oscillation in the wake of the ionization injected electron leads to the effective resonant betatron oscillation, which result in -ray photon energy and peak brilliance beyond that of 3rd generation synchrotron facilities [5]. Finally, an overall comparison is done for the laser-driven Betatron and Inverse Compton Scattering sources.

References

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