New progress of X/ γ ray emission from laser wakefield electron accelerator

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Hard x-ray/ γ -ray emission from laser driven plasmas have a number of interesting applications in the dynamic probing of matter and in medical/biological imaging. Laser accelerator based radiation sources are highly collimated hard x/gamma-ray source with *fs* duration which generated by electron beatron oscillation, Thomson scattering or undulator syncrotron radiation. However, yield and photon energy of these sources are always limited because of controdictory of parameters during acceleration, or unmatched parameters between beam and undulator.

(1) Several methods were proposed by us for improving betatron radiation efficiency [1] or polarization [2]. However, almost all popular methods are based on a single pulse, which is in charge of both electron acceleration and wiggling. To overcome this bottleneck, we present the accelerated electrons wiggling in an external laser field with magnitude one order higher than the self-generated field of bubble (*K* increase 20 times). We acquired the brightness 1.2×10^{23} ph/s/mrad^2/mm^2/0.1%BW at 1 MeV. Such a high brilliant and ultra-fast gamma ray source could be applied to time-resolved probing of dense material [3].

(2) We propose a novel type of undulator that has a period of 100s microns and a magnetic field of 10s Tesla. The undulator consists of a bifilar capacitor-coil target that sustains a strong discharge current that generates a helical magnetic field along coil axis when irradiated by a high-energy laser. Coupling this undulator with laser wakefield accelerators can produce ultra-bright quasimonochromatic x-rays with tunable energy 5-250 keV and optimize the free electron laser parameter and gain length compared with a traditional undulator. This concept may pave a way toward compact synchrotron radiation and even x-ray free electron lasers [4].

(3) We also propose a scheme to efficiently generate gamma rays from sub-μm wires irradiated by petawatt lasers, where electron accelerating, and wiggling are achieved simultaneously. The wiggling is caused by the quasistatic electric and magnetic fields around the wire surface, and these are so high that even QED effects become significant. Gamma rays are generated with brilliance 10^{27} ph/s/mrad^2 /mm^2(0.1%BW) at 20 MeV. The yield efficiency approaches 10%. Such high-energy, ultrabright, fs-duration gamma rays may find applications in nuclear photonics [5].

Based on series of collimated ultra-intense X/gamma ray sources, we start to construct an Ultrafast X-ray Detection User Facility using a PW laser in HuaiRou science city, which is possible to detect the whole dynamic procedure of material within a single laser shot [6], and a 2.5 PW facility in the Laboratory Astrophysics Platform in Tsung-Dao Lee Institute, SJTU.

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