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Research progress of laser-plasma interaction in the 100-TW laser facility at National Central University

Hsu-hsin Chu[1,2], Chih-Hao Pai[1,2], Shao-Wei Chou[1,2], Yao-li Liu[3], and Jyhpyng Wang[1,2,4]
[1] Department of physics, National Central University, Taiwan
[2] Center for High Energy and High Field Physics, National Central University, Taiwan
[3] Institute of Space and Plasma Sciences, National Cheng Kung University, Taiwan
[4] Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan
e-mail (speaker): hhchu@ncu.edu.tw

The 100-TW laser facility is established in 2005 at National Central University in Taiwan. In the first four years, we focused on the construction of an ultrashort, ultra-intense Ti:sapphire laser system with a peak power of 100 TW [1]. After that, we continue upgrading the laser beam quality and stability and performing experiments on laser-plasma interaction.

In the past few years, fruitful results have been achieved in cooperation with Tsinghua University in China and UCLA in America. Firstly, probing of linear plasma wakefields by laser-driven femtosecond electron bunches is demonstrated [2]. With this method, not only the electron density but also the field distribution in the plasma wake can be retrieved from the diffraction pattern of the probing electron beam. Furthermore, the wakefield echo phenomenon was observed for the first time in a plasma density upramp by using this method [2]. Secondly, the generation of ultra-intense single-cycle long-wavelength infrared (LWIR) pulses from a tailored plasma structure is achieved [3]. The normalized vector potential of the LWIR pulse reaches 4, showing that its intensity reaches the relativistic level. It can be used for the self-probing of the nonlinear plasma wake, as demonstrated in Ref [3]. Thirdly, we demonstrate the enhancement of laser-driven betatron x-ray emission by using a density-depressed plasma structure [4]. The betatron oscillation is magnified with a suitable location and depth of the plasma density depression, and thus the increase of output photon number and critical energy. By using such betatron x-ray source, phase-contrast imaging of biological specimens is achieved [5]. The resolution is as small as 5 μm. Such an x-ray source can be applied to high-resolution phase-contrast imaging in biology and material science

On the other hand, we also focus on the research of laser-driven high-harmonic generation (HHG) of EUV/x-ray. A method of single-shot measurement of the HHG temporal envelope is developed by transmission gating of the HHG pulse [6]. Another method of complete 3D phase-matching profile measurement is demonstrated for the optimization of HHG [7]. The effectiveness of this method is verified by a tomographic measurement of the HHG process [7]. Recently, we evaluate the x-ray HHG by using ions as the interacting medium. Our calculation shows that efficient HHG from water windows to keV x-ray can be obtained with transverse quasi-phase-matching [8].

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