Laser-driven high-flux neutron generator

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Compared with charged particles and X-rays, uncharged neutrons have unique penetration and detection capabilities. Neutron-based scattering and diffraction methods are used in a wide range of fields such as medicine, materials science, and energy security. The neutron source driven by intense lasers has the characteristics of small size, short pulse duration, high peak flux and high spatial and temporal resolution, which, brings novel advantages in many prospective applications. Therefore, investigations of high-flux neutron source driven by intense laser pulses have aroused broad interest recently. In this talk, we shall report on our latest theoretical and experimental research progress [1, 2] on laser-driven high-flux neutron sources. A novel compact high-flux neutron generator with a pitcher-catcher configuration based on laser-driven collisionless shock acceleration (CSA) is proposed and experimentally verified. Different from those that previously relied on target normal sheath acceleration (TNSA), CSA in nature favors not only acceleration of deuterons (instead of hydrogen contaminants) but also increasing of the number of deuterons in the high- energy range, therefore having great advantages for production of high-flux neutron source. The proof-of-principle experiment has observed a typical CSA plateau feature from 2 to 6 MeV in deuteron energy spectrum and measured a forward neutron flux with yield 6.6×10^{7} n/sr from the LiF catcher target, an order of magnitude higher than the compared TNSA case, where the laser intensity is 10^{19} W/cm^2. Self-consistent simulations have reproduced the experimental results and predicted that a high-flux forward neutron source with yield up to 5×10^{10} n/sr can be obtained when laser intensity increases to 10^{21} W/cm^2 under the same laser energy.

[1] Y. L. Yao, S. K. He, Z. Lei, T. Ye, Y. Xie, Z. G. Deng, B. Cui, W. Qi, L. Yang, S. P. Zhu, X. T. He, W. M. Zhou, and B. Qiao, Phys. Rev. Lett. 131, 025101 (2023).

[2] Y. L. Yao, Z. B. Wu, T. Ye, S. P. Zhu, X. T. He, and B. Qiao, Phys. Rev. Appl., submitted (2024).