SEMINAR

eli nuclear physics

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High-flux neutron generation by laser-accelerated ions from single- and double-layer targets

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Contemporary ultraintense, short-pulse laser systems provide extremely compact setups for the production of high-flux neutron beams, such as required for nondestructive probing of dense matter or research on neutron-induced damage in fusion devices. Here, by coupling particle-in-cell and Monte Carlo numerical simulations, we examine possible strategies to optimize neutron sources from ion-induced nuclear reactions using 1-PW, 20-fs-class laser systems such as the recently commissioned Apollon laser [1]. To improve ion acceleration, the laser-irradiated targets are chosen to be ultrathin solid foils, either standing alone or preceded by a near-critical-density plasma to enhance the laser focusing.

We compare the performance of these single- and double-layer targets, and determine their optimum parameters in terms of energy and angular spectra of the accelerated ions. These are then sent into a converter to generate neutrons, either traditionally through (p,n) reactions in beryllium or through spallation in lead. Overall, we identify configurations that result in a neutron yield as high as 109 n sr-1 and an instantaneous neutron flux above 1023 n cm-2s-1. Considering a realistic repetition rate of one laser shot per minute, the corresponding time-averaged neutron flux is predicted to reach record values of 7×106 n sr-1s-1, even with a simple thin foil as a primary target. A further boost up to above

5×107 sr-1s-1 is foreseen using double-layer targets with a deuterated solid substrate. Our results draw a pathway for improvement at upcoming 10~PW lasers in which case neutron generation will be more strongly dominated by spallation [2].

[1] K. Burdonov et al., Matter Radiation at Extremes 6, 064402 (2021).
[2] B. Martinez et al., Matter Radiation at Extremes 7, 024401 (2022).