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Bright pulsed point neutron sources using ultra-intense lasers and spherical deuterated capsules

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Laser-driven neutron sources have the unique capability of sub-millimeter source size, allowing access to extremely high peak neutron fluxes (~10^{20} n/cm^2/s) near the target. If a point neutron source can be realized, it could be used for direct measurements of the ion density in ignition-scale ICF fuel. We have investigated monodirectional-drive inertial confinement fusion (ICF) schemes as a possible way to produce bright pulsed point neutron sources for a range of applications. The scheme has been investigated using lasers with non-relativistic intensities (< 10^{18} W/cm^2). We have demonstrated significant neutron enhancement by using relativistic laser intensities (> 10^{18} W/cm^2). The relativistic regime drives a spherical convergence of multi-MeV deuterons by the target normal sheath acceleration (TNSA) in spherical geometry, that leads to efficient DD-fusion reactions with near-peak cross sections. Our experiment at the LFEX laser facility recorded neutron yields in excess of 10^{10} n/sr/pulse by irradiating a Φ500 μm spherical deuterated plastic capsule with a single laser beam with focused intensities around 1×10^{19} W/cm^2. Neutron source size was evaluated by knife-edge proton radiography. Since DD reactions produce neutrons and protons with almost the same probability, protons are assumed to originate from the same region as neutrons. Proton radiographs were captured on a radiochromic film (RCF). The source size was estimated from the spatial resolution of the shadow of the knife edge. In the presentation, we present the details of the analysis and future application prospects of this scheme.

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