Enhanced proton-boron fusion in laser-modulated plasma

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Aneutronic and nonradioactive properties make proton and boron advanced fusion fuels for ideal energy source production through reactions following $p+^{11}B \rightarrow 3\alpha$ (p-^{11}B). However, it is extremely difficult to achieve fusion ignition, since the intrinsic restriction on the p-^{11}B cross-sections. To solve the contradiction between the clean fuel requirement and low cross sections, it is essential to modulate the reaction dynamics, especially by taking the advantage of the resonant feature of the p-^{11}B reactions.

In this work, we experimentally studied the p-^{11}B reactions generated by a proton beam and boron plasma triggered by two laser pulses respectively. The α particle yield has been increased in the boron plasma by an order of magnitude or more, compared with a cold boron target with an equivalent nucleus quantity. We mainly attribute this to proton wiggler induced by strongly modulated electro-magnetic field distribution from the blow-off plasma produced by unsteady laser ablation, which may enhance the collision frequency between protons and boron nuclei. Furthermore, enhancement of the resonant reactions at $E_{c.m.}$ = 148 keV has been observed at the end of the boron-heating laser pulse, which could be explained by the relative velocity shift due to the thermal motion of the nuclei. This work could benefit understanding of the plasma effects on nuclear reaction dynamics, and also enable opportunities to explore physics in the inertial confinement fusion associated with proton-driven fast-ignition.