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Laser parameter design for the DCI laser fusion

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Double-cone ignition (DCI) scheme [1] was proposed as an alternative fast-ignition direct-drive laser fusion to achieve a high-density plateau around the compressed target center and a high laser-to-target-center energy coupling via magnetically guided heating. Since 2020 serval rounds of DCI experimental campaigns have been conducted in Shenguang II upgrade (SG-II-U) facility and its feasibility has been confirmed. Furthermore, the DCI scheme, the implosion is implemented in double cones as a small part of a sphere to reduce the ns laser energy. The double cones bring two more advantages. First, the DT gas does not need to fill in the target center, so isochoric plasma around the target center could be obtained. Second, the high density plasma is formed after collision of the plasma jets from the double cones, which means that the time of the heating cone experiencing high pressure is substantially reduced. Our experiments and simulations showed the stagnation of the plasma jets is around 0.2 ns according to our experiments and simulations. By contrast, in the standard fast ignition scheme, the heating cone must experience the whole implosion of 10 ns. In principle, this can strongly reduce destruction of the heating cone in the DCI scheme.

To further study the DCI scheme, we have recently developed an integrated simulation approach for the whole processes of the DCI scheme. Recently, we have used the integrated simulation to reproduce our experiments of Round 6 to Round 8 and the agreement between experiments and simulations suggests that our integrated simulation is reliable. Then, we used the integrated simulation to predict the DCI ignition requirement of the ns implosion and ps heating laser parameters, which have been applied in the phase II of the upgrading plan of SG-II-U. For this phase of facility, we designed to mix second-harmonic and fundamental ps lasers for efficient heating and electron spectrum control. This is based on the finding of electromagnetically induced transparency (EIT) in relativistic plasma in recent work [2], where we proved that EIT found in atom physics can also happen in plasma physics and we developed a three-wave coupling model to relativistic regime, explain this phenomenon, and present the condition for EIT happening. For the Phase I of the upgrading of SG-II-U, we designed the optimized ps laser angles to enhance the electron yield and spectrum hardness, based on the transverse interference of two ps lasers [3].

References

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