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Energy coupling and transportation in the double-cone ignition scheme

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In inertial confinement fusion research, ignition requires to achieve energy-balanced relationship among the driver, fusion output and various categories of energy loss. The double-cone ignition (DCI) scheme has been proposed [1], aiming at reducing the requirement for the driver energy while controlling the energy loss through laser-plasma and hydro-dynamic instabilities. In the scheme, conical implosions of spherical shells embedded in two head-on gold cones are driven by specially shaped nanosecond (ns) laser pulses. During the implosions, energy is transferred to a supersonic jet at the cone-tip, which then forms a high-density plasma core through head-on collisions with the jet from the other cone-tip. At last, the core is heated by picosecond-laser-driven fast-electron beams guided by strong magnetic fields, and reaches the condition for ignition.

During the 2021-R7 DCI experiment, a comprehensive set of measurements tracking the flow of energy from the laser to the fast-heated plasma core has been conducted. The ns laser energy absorption and global spatial distribution of scattered energy have been measured. The total scattered energy indicates the laser absorption has reached 90%, with underdeveloped laser-plasma instabilities. Allocation of absorbed energy to exhausting and implosion, and energy transmission to the plasma jet during conical implosion have also been investigated, which reveal the primary restriction on energy conversion to the colliding plasma is the shell mass reduction inside the cone. From characterization on the temperature and areal density of the plasma core at the cone-tip, it is found the conversion efficiency from the picosecond laser energy to internal energy is above 16%, through injection of a fast-electron beam with moderate temperature. This investigation could provide insights into the energy flow trajectories in the DCI scheme.

References

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