Physics > Plasma Physics

Fast-ignition design transport studies: realistic electron source, integrated PIC-hydrodynamics, imposed magnetic fields

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Transport modeling of idealized, cone-guided fast ignition targets indicates the severe challenge posed by fast-electron source divergence. The hybrid particle-in-cell [PIC] code Zuma is run in tandem with the radiation-hydrodynamics code Hydra to model fast-electron propagation, fuel heating, and thermonuclear burn. The fast electron source is based on a 3D explicit-PIC laser-plasma simulation with the PSC code. This shows a quasi two-temperature energy spectrum, and a divergent angle spectrum (average velocity-space polar angle of 52 degrees). Transport simulations with the PIC-based divergence do not ignite for > 1 MJ of fast-electron energy, for a modest 70 micron standoff distance from fast-electron injection to the dense fuel. However, artificially collimating the source gives an ignition energy of 132 kJ. To mitigate the divergence, we consider imposed axial magnetic fields. Uniform fields ~50 MG are sufficient to recover the artificially collimated ignition energy. Experiments at the Omega laser facility have generated fields of this magnitude by imploding a capsule in seed fields of 50-100 kG. Such imploded fields are however more compressed in the transport region than in the laser absorption region. When fast electrons encounter increasing field strength, magnetic mirroring can reflect a substantial fraction of them and reduce coupling to the fuel. A hollow magnetic pipe, which peaks at a finite radius, is presented as one field configuration which circumvents mirroring.

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