Characterization of laser-produced fast electron source for integrated simulation of fast ignition

A. Debayle[1], J.J. Honrubia[1], E. d'Humières[2], V.T. Tikhonchuk[2]

[1] *ETSI Aeronáuticos, Universidad Politécnica de Madrid, Spain*

[2] *CELIA, Université Bordeaux 1-CNRS-CEA, Talence, France*

Relativistic electron currents ($\sim 10\text{kA}\ \mu\text{m}^{-2}$) are produced by focusing an intense laser beam ($I \geq 10^{19}\,\text{W cm}^{-2}$) on a solid target. Based on this mechanism, an original inertial confinement fusion scheme has been proposed which consists in heating the compressed deuterium-tritium core with a laser-produced electron beam. Experimentally the fast electron source is not well characterized and simulations of both electron generation and transport remain a difficult task. Generally, transport codes are used with a simplified fast electron source as initial condition. The fast electron spectrum is assumed to be exponential with an adjustable temperature, and the divergence is characterized by a dispersion angle. To verify these assumptions, we have performed a characterization of the laser-driven fast electron source by means of PIC simulations [1] in the cases of a planar foil and a double cone.

It is found in simulations with foils that the fast electron beam has both a dispersion angle and a radial velocity right behind the laser/plasma interaction region. The divergence component is enhanced when preplasma is present, decreasing strongly the resistive magnetic field generation in the dense regions. The fast electron spectrum is characterized by a power law at low energy while it presents an exponential behaviour at high energy. The beam energy deposition in the dense plasma is slightly modified compared to that estimated with an exponential spectrum. In the case of double cone, the laser illumination in cone tip inner surface is stronger due to the guiding cone effect. The dispersion angle increases since the Weibel instability generated magnetic fields at the laser/plasma interaction region responsible of electron scattering [2] , are higher. The fast electron radial velocity is also increased due to the non-uniform hole boring that bends the relativistic critical density surface. In the cone case, the beam radius is smaller because of the guiding effect. Application of these results to integrated simulations of deuteurium-tritium ignition with a double cone is also discussed. It is found that the coupling efficiency between fast electron beam and dense core decreases as the radial velocity increases.

References

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