Integrated simulations of fast ignition of inertial fusion targets

Javier Honrubia

School of Aerospace Engineering, Universidad Politécnica de Madrid, Madrid, Spain

Inertial Confinement Fusion (ICF) intends to trigger thermonuclear fusion reactions in a few milligrams of Deuterium-Tritium (DT) contained in a 1 - 2 mm radius hollow spherical microcapsule. In 2009, the National Ignition Facility (NIF) started its operation at the Lawrence Livermore National Laboratory in Livermore (California) intending to demonstrate the scientific feasibility of ICF. So far, the NIF has achieved the record of producing more energy by fusion reactions than the energy stored in the DT [1]. However, the difficulties found in achieving ignition and moderate energy gain have led to new target designs as well as to envision alternative ignition schemes [2].

One of the leading scientific attractive of the ICF is the broad range of densities and temperatures found in fuel targets, which go from ideal low-density plasmas in the laser interaction region to degenerate plasmas at densities higher than 10^3 times the solid density in the igniting fuel. Also, the ICF target evolution implies physical phenomena with very different space and time scales, which go from femtoseconds (fs) to nanoseconds (ns). Some of these phenomena are ultra-intense laser-plasma interactions (fs), multi-dimensional radiation-hydrodynamics (ns), transport of laser-driven supra-thermal electrons (ns) and fusion reactions (ps).

Fast ignition of fusion targets is an excellent example of the multiple time scales found in ICF. It consists of separating fuel compression from the ignition. Fuel compression is produced by laser pulses of intensities about 10^{14} Wcm^{-2} and durations of tens of nanoseconds, while the ignition hot spot is generated by ultra-intense laser pulses of 10^{20} Wcm^{-2} with picosecond duration. Simulations of fast ignition of fusion targets carried out at the *MareNostrum* and *Magerit* HPC facilities will be presented [3,4]. They comprise multi-dimensional radiation hydrodynamics, Particle-In-Cell and hybrid simulations of fast ignition of imploded ICF capsules.

References

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