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(I) Modelling laser plasma interaction for inertial confinement fusion experiments

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The inertial confinement fusion scheme relies on the implosion of a Deuterium-Tritium pellet by the means of tens of laser beams. At maximum of compression, extreme thermodynamic conditions must be reached in order to trigger a thermonuclear wave. Laser-plasma interaction, for such large spatial and temporal scales, may only be described numerically with specific hydrodynamic codes. In the latter, only the laser beams refraction, and energy deposition due to inverse bremsstrahlung, are accounted for. Alas, such a description is incomplete as laser-plasma interaction may trigger to a plethora of physical effects leading to the loss of laser energy. Chiefly, the coherent laser light may be scattered in different directions through wave mixing processes such as Raman or Brillouin back and side scattering, cross beam energy transfer and collective scatterings.

Postponing the description of non-lineal kinetic effects, we recently developed a Monte-Carlo algorithm to describe any kind of convective wave mixing process involving two[1] or more electromagnetic waves and one driven electrostatic wave. The laser beams, described by large bundle of rays, can suffer scattering by any kind of wave coupling phenomenon. In the case of Brillouin backscattering, an incoming ray has a given probability to be scattered, as a collision, in the backward direction by the driven acoustic wave. As all these scatterings are stimulated, the probability of ray deflection depends on the scattered light amplitude. This non-linearity is addressed by means of a fixed-point iteration method. At a given hydrodynamic map, the raytracing is performed several times to estimate the light intensities at each cell, until convergence of the stationary solutions. To date, our method includes: 1°) Raman back and side-scattering, 2°) Brillouin back and side-scattering, 3°) the energy exchange between laser beams and scattered lights, 4°) the collective scattering in which an electrostatic wave is shared by a cone of laser beams.

[1] A. Debayle et al., Phys. Plasmas 26, 092705 (2019)

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