A transport simulation code for inertial confinement fusion relevant laser-plasma interaction

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The forthcoming laser installations related to inertial confinement fusion (ICF), LMJ (France) and NIF (USA), require multi-dimensional numerical simulation tools for interpreting current experimental data and to perform predictive modelling for future experiments. Simulations of macroscopic plasma volumes of the order of 0.1 mm^3 and laser exposure times of the order of hundreds of ps are necessary. Large-scale first-principle approaches like PIC or Fokker-Planck calculations are at present not feasible due to computational constraints. Macroscopic modelling of laser-plasma interaction in ICF-context is based at present on reduced physics models (coarse-graining).

We present a new code for laser-plasma interaction which contains the relevant physics. The laser field is treated in a paraxial approximation using the existing code PARAX. The plasma response is given by a single-fluid, two-temperature, fully non-linear hydrodynamical code (MPL) in the plane transverse to the laser propagation axis. MPL uses a Lagrangian, discontinuous Galerkin-type approach for unstructured meshes, which allows efficient and accurate treatment of strong plasma depletions (e.g. due to strong self-focusing) and strong shocks (of a plasma expelled from laser filaments) with a relatively small number of mesh points. The code also accounts for the dominant non-local transport terms in spectral form originating from a linearized solution to the Fokker-Planck equation. Raman and Brillouin backscattering are available in a local 3-wave model where each wave is treated in the paraxial approximation. The code has been fully parallelized using MPI and FFTW. The simulations of interest lie with conditions as they are encountered in hohlraun plasmas in the case of indirect drive or the plasma corona for direct drive. Two fundamental applications of interest are presented: the nonlinear evolution stage of the plasma under non-local transport conditions and the mechanism of plasma-induced optical smoothing.