High-performance simulation of ultra-short laser pulses action on matter: achievements and problems

Levashov P.R.

pasha@ihed.ras.ru

Joint Institute for High Temperatures RAS, Moscow, Russia

Problems dealing with action of laser radiation on matter have numerous applications in science and technology. Processing of materials, sources of electromagnetic radiation, acceleration of charged particles, generation of superstrong magnetic fields, biological and medical applications are only some of the issues in which interaction of laser radiation with different materials plays a crucial role. Nevertheless, owing to the extreme complexity of this phenomenon a full-scale simulation of the action of laser radiation on matter is of substantial difficulty up to nowadays. In the framework of the continuum approach it is necessary to know the whole set of thermodynamic, transport and kinetic properties, as well as a number of kinetic models including ionization and defragmentation of matter. In kinetic models only collisionless relativistic plasma is usually considered owing to complexities with a correct consideration of collisions. Atomistic methods have significant difficulties in the description of an electronic subsystem.

The presentation will attract the experience of quantum calculations of thermodynamic, transport and optical properties of substances in a wide range of parameters, including the two-temperature case, using supercomputers. Some problems appearing at continuum parallel simulation of problems of laser radiation action on matter using the adaptive mesh refinement technique as well as in the kinetic modeling of acceleration of electrons and protons under the action of ultrarelativistic laser pulses by the particle-in-cell (PIC) method will be discussed.