Kinetic Simulation Of Heat Transport In Collisional Laser Produced Plasmas

Irina Potapenko[1,2], Andrey Brantov[2,3], Valeriy Bychenkov[2,3] and Stanislav Karpov[2]
[1]*Keldysh Institute of Applied Mathematics RAS, 125047 Moscow, Russian Federation*
[2]*Dukhov All-Russia Research Institute of Automatics, 127055 Moscow, Russian Federation*
[3]*P.N. Lebedev Physical Institute, RAS, 119991 Moscow, Russian Federation*

Since the early 1970s, in connection with the development of laser technology and the performance of the first ICF experiments, interest in the problem of interaction of intense laser radiation with plasma increased substantially. Such interaction results in the appearance of high temperature and density gradients, which casts doubts on the possibility of describing actual laser experiments in the framework of the classical transport theory. To date, there are a lot of experimental data [1] confirming the idea about the nonlocal character of heat transport in laser produced plasmas. This concerns, first of all, the description of the heat flux, because the electron heat transport plays a crucial role in the energy balance in laser produced plasmas. The problem of the heat flux intensity is one of the key problems to be solved for successful implementation of inertial confinement fusion (ICF), because most energy of the incident laser radiation is absorbed near the critical density (i.e., far from the ignition region) and is then carried deep into the plasma by the electron heat flux, which determines the heating rate, temperature, and compression ratio of the target.

The analytical theory of nonlocal transport is designed only for the small temperature perturbations [2]. So the only way to calculate the parameters of the heat transport in plasma with the temperature inhomogeneity scale length less or equal to one hundred electron mean free path lengths is the numerical simulation of the kinetic equation with Landau-Fokker-Planck collision operator.

We suggest an effective approach to the numerical solution of the plasma kinetic equation that is based on a new DSMC method [3, 4] for the nonlinear collision operator. For wide range of parameters the relaxation of the initial temperature perturbation in a collisional plasma is investigated in 1D3V geometry. The obtained numerical results are compared with many various transport models which describe the process with some differences. A good agreement with nonlocal heat transport model [5] is found. Also the heat wave propagation from the heating region deep into the plasma is considered. The temperature profile and flux dependence on time is examined. The structure of the temperature wave front, particularly, the difference from the hydrodynamic description is investigated.

[1] R.E. Harrington, *Journal of Appl. Phys.* **37**, 2028 (1966).
[2] S. Brunner, E. Valeo, *Phys. Plasmas* **9**, 923 (2002).
[3] A.V. Bobylev, I.F. Potapenko, S.A. Karpov, *AIP Conference Proceeding* **1501**, 541, (2013)
[4] A.V. Bobylev, I.F. Potapenko, *J. Comp. Phys.* **246**, 123 (2013)
[5] A. Marocchino et al., *Phys. Plasmas* **20**, 022702 (2013)