Physics of laser plasma interaction and particle transport in the context of inertial confinement fusion

Vladimir TIKHONCHUK

Centre Lasers Intenses et Applications, University of Bordeaux – CNRS – CEA, France
E-mail: tikhonchuk@u-bordeaux.fr

Lasers are unique tools for transporting extremely high powers to large distances, but transfer of these powers to matter in small volumes is a very complicated problem. First of all, these processes are a very far from equilibrium, as with photons having energy of a few electron-volts we would like to heat plasma to temperatures thousand times higher. Second, these processes are strongly non-linear, as they correspond to a transfer of energy of a large number of photons to much smaller number of particles in extremely small volumes and in a very short time scales. The idea of inertial confinement fusion gave a strong push for studying all these processes in detail, and now, although many issues remain to be resolved, we have quite good understanding of how they operate in ICF conditions and what limitations and advantages they offer. I had an opportunity to participate in these studies from the beginning of 1970s and can share several personal recollections of almost 50 years history.

The processes of laser plasma interaction and particle transport operate on the micrometric and picosecond time scales, which are about two orders of magnitude smaller than the scales of the ICF targets. This disparity of scales makes so difficult communications between the world of hydrodynamics and the world of these “anomalous” processes. Although the physics of parametric instabilities and kinetic particle transport has been developed rather rapidly, its implementation in the ICF phenomenology is still under way. We still have serious problems with development of multi-scale physics and understanding of intricate interaction between the microscopic and mesoscopic levels. In this talk I will give several examples of the phenomena where such an interaction was successful and allowed to improve the hydrodynamic performance by controlling the microscopic processes, and also the examples where the mother-nature did not allow us to access the performances we wish.

This analysis allows us to foresee the future developments necessary for ICF success. The key points are the multi-scale modeling and thoroughful validation of our numerical tools in dedicated experiments. Reduced models retaining to major elements of microscopic physics and operating inline with the macroscopic hydrodynamic codes, which are under development today, will allow us to have predictive numerical tools for design of ignition-scale targets.