Alternative schemes for the inertial fusion energy

V.T. Tikhonchuk

Centre Lasers Intenses and Applications, University Bordeaux 1, Talence, France

Abstract

Ignition of controlled thermonuclear reactions will be demonstrated at the National Ignition Facility (NIF) next two years. The target indirect drive scheme on NIF is chosen because of its robustness, but its performance is limited to modest gains of the order of ten, which are not sufficient for energy production. More efficient indirect drive schemes are under consideration now in the context of the LIFE project.

Alternative targets designs requiring a lower laser energy for ignition and promising gains of the order of hundred or more have been proposed last years. They can be tested on the NIF and the most efficient of them can be chosen as a baseline for the future power plant demonstrator. These advanced ignition targets are based on schemes that are separating the stages of the fuel assembly and ignition. The compression of the fuel will be accomplished at lower implosion velocities assuring a better stability. The fast fuel heating requires much higher laser powers and high precision energy deposition. Both issues present serious scientific and technological challenges, which need to be studied in detail.

In this presentation I will discuss the characteristic features of alternative ignition schemes by considering three approaches that are under development within the European IFE project HiPER. These are: the fast ignition schemes with energetic electrons and ions and the shock ignition scheme. The fast ignition schemes consider creation of an ignition spot off the target center by depositing the energy of charged particles in a small volume of a compressed fuel. These schemes require laser powers at the 10 PW scale or more and a good control of laser plasma interactions in the relativistic domain: efficient transformation of the laser energy into charged particles, collimated transport and well-controlled energy deposition. Some of these issues are already tested in small-scale experiments, which are demonstrating an efficient laser energy conversion in electrons, but pose serious problems with their transport to the core. On the contrary, the ion transport can be better controlled, however, the transformation efficiency is insufficient.

The shock ignition scheme relies on the power amplification of a strong shock wave launched with an additional laser pulse in the end of compression phase. It requires lower laser powers at the level of 300-400 TW, which are accessible already on the NIF, and it proposes to boost the fuel temperature in the central hot spot. The hydrodynamic simulations of the target implosion and the fuel heating demonstrate that the shock collision plays a stabilizing role in the hot spot dynamics. The problems that are less understood today are related to coupling of the laser spike energy to the target and to the energy transport by hot electrons.

Finally, the major experimental work planned for studies of alternative ignition schemes will be shortly discussed.