Fast central Ignition of inertial confinement targets by ion beam

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Ion beam heating the central region of pre-compressed inertial confinement fusion (ICF) target without using the guide channel seems today the most promising method for fast ignition. This paper presents the results of sustainable numerical modeling the entire evolution cycle of ICF target fast ignited by ion beam. Such a hybrid calculation includes the three steps. The first one is modeling by means of the 1D hydrodynamic code DIANA [1] the spherical compression of ICF target. The main yield consists in the density and temperature distributions in the moment of maximal compression. The second step is modeling by means of the 1D kinetic code BIN [2] the ion beam heating of inhomogeneous immobile plasma with a thermodynamic state calculated on the first step in the moment of maximal compression. The main yield consists in the temperature distribution in the compressed target heated by ion beam. The final step is modeling by means 1D hydrodynamic code TEPA [3] the thermonuclear combustion of the target with the initial density distribution obtained on the first step and the temperature distribution obtained on the second step. The total gain as the ratio of yielded fusion energy to the aggregated energy of laser pulse and igniting ion beam is calculated.

The basic target of the European project HiPER directed to fast ignition with the energy of compressing laser beam of EL≈130 kJ as well as the non-cryogenic target with deuterium-tritium hydride of beryllium (BeDT) fuel with the energy of compressing laser beam of EL≈1.3 MJ were chosen as the objects of study. The beams of light, medium and heavy ions such as carbon, vanadium and gold were considered.

The maximal gains of the HiPER and BeDT targets equal, respectively, to 60 and 30 were calculated. The analysis shows that if the energy of beam ions is enough to create the temperature Bragg peak in the center of a target, the differences in the type of ions have a secondary importance. The dependences of igniting ion beam energy and thermonuclear gain on the width of the Gaussian spectrum of ions were established. The influence on ignition of the spatial temperature and density distributions of preliminary compressed target is discussed. The existence of a hot spot in the center of compressed ICF target with the temperature of several keV, which is the natural result of spherical implosion, reduces the energy of igniting ion beam and reduces the requirement for the allowable width of ion’s spectrum.

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