FUSION IGNITION IN INDIRECT-DRIVE TARGETS UNDER THE CONDITIONS OF SPHERICALLY INJECTED SECOND-HARMONIC LASER LIGHT

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Overcoming the ignition threshold in inertial confinement fusion systems is a challenging problem in fundamental and applied science and engineering, which is associated with small target sizes, power and energy limitations of laser facilities, and a number of other reasons. The ignition process is associated with spontaneous explosive combustion of thermonuclear fuel in a small volume and is characterized by a sharp increase in energy release in it, which opens up opportunities for studying various issues of high energy density physics. This problem was first solved in 2021–2022 by LLNL specialists: in experiments at the NIF facility, thermonuclear energy release exceeded the energy of deposited laser radiation [1].

The design of the NIF laser facility is based on the cylindrical injection of laser light with a wavelength of 0.35 μm (third harmonic). Reaching ignition at megajoule laser facilities with design features other than NIF, however, is free of fundamental problems and reduces to producing the required level of energy and power in the laser system. For example, an alternative geometry of laser drive is spherical input, which provides a more symmetrical effect on the target. This alternative is taken into account by specialists from Russia and China when considering the possible construction of megajoule laser facilities in these countries in the future. A multiple increase in the initial harmonic of the neodymium laser (1.05 μm) is designed to reduce the influence of nonlinear processes during the interaction of laser radiation with plasma. However, this conversion is accompanied by noticeable losses of initial radiation energy. In this case, the energy losses increase with the multiplicity of the harmonic transformation [2].

This report discusses the possibilities of igniting indirect-drive targets with spherically injected laser light with a wavelength of 0.53 μm (second harmonic). A general approach to the design of targets is discussed, which makes it possible to fully reveal the advantages and neutralize the disadvantages of such a configuration of laser system parameters. According to calculated data, the tuned effect in the spherical target with a radius of about 7 mm completely prevents overlapping of laser paths with plasma up to a time of about 9.5 ns, which creates extremely favorable conditions for ignition. The preliminary data indicate that a laser system with an energy of about 3 MJ and a total power of 500 to 600 TW is capable of igniting cryogenic capsules with a radius of about 1.7 mm in the above configuration of the laser facilities and target parameters. At the same time, the neutron yield in such targets, according to the calculated data, reaches values of the order of 10^{19}, which corresponds to a fusion energy release of 30 MJ.

References

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