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NUMERICAL MODELING OF LASER COMPRESSION OF SPHERICAL SHELLS IN THE PROBLEM OF LASER THERMONUCLEAR FUSION *)

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Laser fusion research studies spherical compression thin shell targets using powerful multi-beam lasers-drivers (see, for example, [1, 2]. For obtaining of useful energy it is assumed use a hybrid designs of fission-fusion reactor [3, 4]. In such reactors, it is sufficient to achieve the "parameter ignition" $G=E_f/E_l>3$, E_f - released thermonuclear energy, E_l - absorbed energy of laser [4]. Calculations were performed using 2D code "Atlant Sp" [5, 6]. The temporal shape and energy of the laser pulse were fixed, $t_1=8$, $t_2=10$, $t_3=11$ *ns*, $E_{las}=1$ MJ, but the wavelengths of the radiation varied 1) λ= 0,351 μm – third harmonic of the glass Nd laser, and 2) λ= 0.25 μm – the first harmonic of the gas excimer KrF- laser. At a fixed energy and temporal pulse shape, the target parameters (R_1, R_2) were varied.

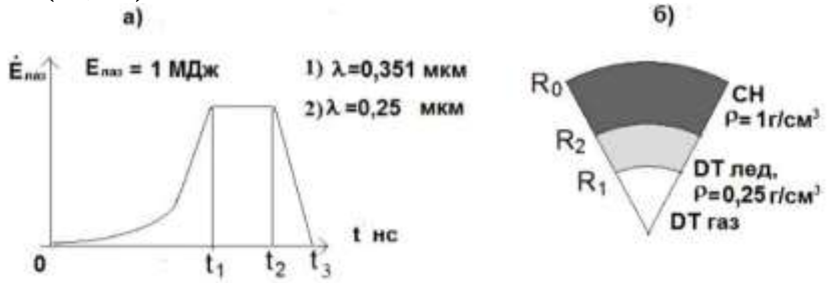

Fig.1 Temporal shape of the laser pulse (a). Design of a cryogenic shell target (b).

The shell had an initial radius R_0 and thickness (R_0-R_2), an initial density of 1 g/cm^3, thickness of DT ice (R_2-R_1) with a density of 0.25 g/cm^3. The target parameters for λ = 0.351 μm were taken from [6] and were selected so that the moment of target collapse fell within the time interval [t_2, t_3]. R_0=0.2, R_2=0.1965 cm, on the inner surface of which a mixture of deuterium and tritium with a layer thickness of R_2–R_1=9 μm is frozen, and in the central region there is deuterium-tritium vapor with a density of $7\cdot10^{-5}$ g/cm^3.The possibility of using a KrF laser as a driver for a hybrid reactor was discussed in [4, 8]. Numerical calculations compared the yield of thermonuclear energy in targets of the design described above in two cases: 1) λ = 0.351 μm and 2) λ = 0.25 μm. In case 1) G= 1.5 and t_c= 100 ns (target collapse time), and in case 2) G=1.9, t_c = 95 ns. It is possible to increase G by matching the target compression time with the laser pulse duration without increasing the radius and aspect ratio of the shell.

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References

[1]. Basov N.G., Subbotin V.I., Feoktistov L.P. Bulletin of the Russian Academy of Sciences, 1993, 63(10).
[2]. Lebo I.G. Russian technological magazine. 2023, 11(3).
[3]. Kuzenov V.V., Lebo A.I., Lebo I.G., Ryzhkov S.V. Physico-mathematical models and methods for calculating the impact of powerful laser and plasma pulses on condensed and gaseous media. M: Publishing house of MSTU im. N.E. Bauman. 2015.
[4]. Dolgoleva G.V., Lebo A.I., Lebo I.G. Math modeling. 2016. 28(1), 23.

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