eneration of thermonuclear neutrons by laser ction on a conical target

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A yield of 3×10^4 neutrons from a conical target filled with deuterium was observed following the action of laser radiation of intensity 10^{11} W/cm^2.

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Successful experiments on the compression and heating of a deuterium plasma inside a conical arget by an electron beam[1] prompted us to assess the possibility of initiating a thermonuclear eaction in such a target with the aid of laser radiation. Interest in conical targets, in which an lement of a convex spherical shell—piston—is driven inside a conical cavity that has been pressed nto a heavy material and filled with gaseous fuel, is due to the fact that such targets seem to be ble to simulate spherical compression at an equivalent energy larger by a factor $4\pi/\Omega$ than the ctual applied energy (Ω is the solid angle of the cone).

We used in the experiments a neodymium-glass laser installation with an emission energy up o 30 J at pulse duration 5 nsec and up to 80 J at 25 nsec. The experiments were performed with argets pressed into lead and closed with a lavsan polyester shell 5 μm thick and with a radius urvature 1.7 mm, the same dimension as the generatrix of the cone. The cone apex angle was 53°. he radiation was focused on the target in vacuum by a lens of $f=30$ cm. The laser-beam diameter n the lens was 5 cm. The focus of the lens was 9 mm behind the target shell.

The neutrons were registered with a scintillation detector consisting of a plastic block measurng $50\times50\times12$ cm and two FÉU-49B photomultipliers shielded with a steel cover. The lifetime of he thermal neutrons in the detector moderator was 200 μsec, the detector efficiency was 0.01, and he background was 8 counts in 400 μsec. The detector was placed 40 cm behind the target. The arget and the detector were separated by a layer made up of lead, brass, glass, and steel with a otal thickness 12 cm.

The largest neutron yield, $(2.6\pm0.2)\times10^4$ neutrons, was registered when laser radiation of nergy 70 J and duration 25 nsec was applied on a target filled with D_2 at a pressure 1 atm. The nitial section of the oscillogram of the signal from the neutron detector is shown in Fig. 1a. In hese experiments, the leading front of the laser puslse was shortened with the aid of an aluminum lm on lavsan[2] (Fig. 1b). As the result of the action, the cone apex became rounded with a harcteristic dimension 200 μm (Fig. 1c).

The observed neutron yield did not permit a detailed quantitative investigation of the influnce of various experimental conditions. It was only established that the shortening of the duration f the laser pulse to 5 nsec with decreasing total energy to 30 J has led to practically complete anishing of the neutrons.

From the obtained data we can estimate the fraction of the laser energy converted into nternal energy of the plasma. The expression for the neutron yield is $N=0.5n_D^2\epsilon\langle\sigma v\rangle\tau V_0$ where n_D nd V_0 are the initial density and volume of the thermonuclear fuel, and τ is the reaction time.

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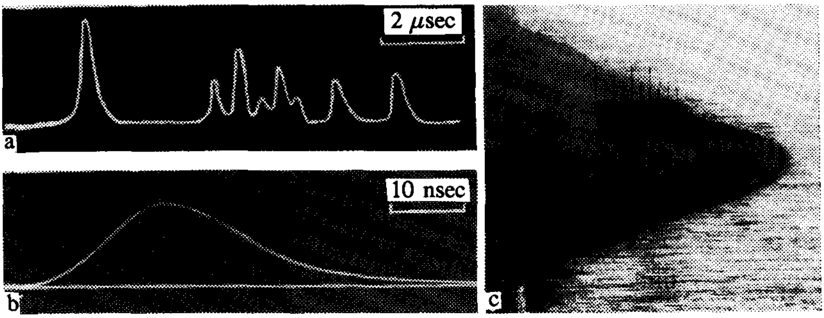

FIG. 1. a) Oscillogram of signal from neutron detector, b) oscillogram of laser pulse, c) section through conical cavity after bombardment of the target; each division is 10 μm.

According to the experimental data, the degree of compression ϵ can lie in the range $10^2 \lesssim \epsilon \lesssim 10^3$ From the known dependence of $\langle \sigma v \rangle$ on T_i,[3] we find that the ion temperature should be $200<T_i$ <300 eV and depend little on the values of ϵ and τ. To heat the entire mass of the D_2 to suc temperatures the energy required is 5–8 J.

The estimate shows that 8–14% of the laser-radiation energy should be converted into th energy of the compressed plasma. For comparison we note that in symmetrical compression o microspheres by laser radiation of energy 60 J and duration 200 psec, the corresponding conversion coefficient is only 0.1%.[4] The difference between the conversion coefficients can be partiall caused by the appreciable decrease in the losses due to reflection and refraction when conica targets are heated at small light fluxes.

The decreased neutron yield observed by us when the laser-pulse duration was decreased i apparently due to the decrease in the amount of evaporated piston material and the correspondin decrease of the hydrodynamic efficiency.

Thus, the experimental results show that action of laser radiation of moderate intensit ($\sim 10^{11}$ W/cm^2) on relatively large conical targets leads to a sufficiently effective initiation of thermonuclear reaction. To understand the hydrodynamics of the compression, the heating, th thermal conductivity, and other processes that occur in this case, further experimental and theoretical investigations are necessary.

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