Production of a hot plasma during indirect illumination of microballoons at the Iskra-5 laser installation

F. M. Abzaev, V. I. Annenkov, V. G. Bezuglov, S. A. Bel'kov,
A. V. Bessarab, A. V. Veselov, V. A. Gaïdash, I. V. Galakhov, I. P. Guzov,
N. V. Zhidkov, V. M. Izgorodin, V. A. Kargin, G. A. Kirillov,
V. P. Kovalenko, G. G. Kochemasov, V. A. Krotov, A. V. Kunin,
V. P. Lazarchuk, D. N. Litvin, L. V. L'vov, S. P. Martynenko, M. R. Mochalov,
V. M. Murugov, L. S. Mkhitar'yan, N. A. Nitochkin, G. P. Okutin,
V. A. Osin, V. I. Pankratov, A. V. Pinegin, S. I. Petrov, V. T. Punin,
V. G. Rogachev, A. V. Ryadov, A. V. Senik, A. B. Smirnov, S. K. Sobolev,
I. I. Solomatin, N. A. Suslov, V. A. Tokarev, A. N. Fedotov,
V. A. Khrustalev, N. M. Khudikov, V. S. Chebotar', and N. A. Cherkesov

All-Russian Scientific-Research Institute of Experimental Physics,
607200 Arzamas-16, Nizhniĭ Novgorod Oblast, Russia

(Submitted 5 May 1993)
Pis'ma Zh. Eksp. Teor. Fiz. **58**, No. 1, 28–30 (10 July 1993)

The first experiments have been carried out on the hot plasma produced during indirect illumination of microballoons containing a gaseous DT mixture at the Iskra-5 laser installation. The integrated yield of DT neutrons reached 6×10^9 per pulse.

A series of first experiments with indirect (x-ray) bombardment of shell microballoons containing a gaseous DT mixture has been carried out at the Iskra-5 high-power iodine laser installation. In targets of this design, the x radiation is formed in a converter cavity made of a material with a high atomic number. The laser light enters the cavity through holes whose total area amounts to only a small fraction of the overall surface area of the converter.

This bombardment method makes it possible to substantially improve the symmetry of the compression of the microballoons, even if the laser beams are positioned asymmetrically and even if these beams are of relatively low quality. This method has been used in experiments at the largest laser installations: NOVA (in the US),[3] Gekko 12 (Japan),[4] and Febus (France)[5] at energies of 5–20 kJ and at a wavelength $\lambda=0.53$ μm or $\lambda=0.35$ μm.

In the present experiments the laser wavelength was $\lambda=1.315$ μm. Furthermore, in contrast with these earlier studies, in which the converter cavity was bombarded by two clusters of beams, we used the more symmetric 12-beam arrangement of the Iskra-5 installation. With this combination of beam arrangement and target geometry, we expected the bombardment of the DT-filled microballoon to be uniform within 3%.

The laser beam energy delivered to the target was $E_t\simeq 9$ kJ at a pulse length of 0.3 ns. The change in the target construction made it possible to vary the specific energy deposition in the microballoon containing the gaseous DT mixture. To study the

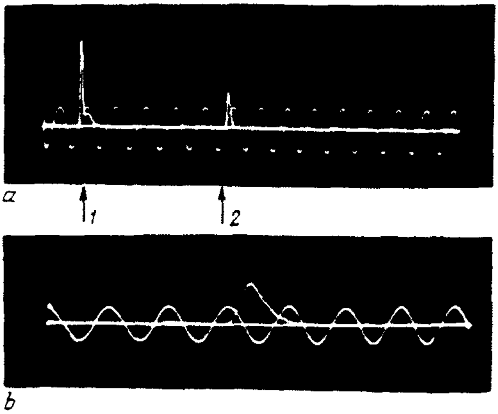

FIG. 1. Results of neutron measurements by a time-of-flight technique at a distance $L = 12.5$ m from the target. a: Panoramic oscilloscope trace. *1*—x-ray pulse; *2*—neutron pulse. The marker frequency is 25 MHz. b: Distribution of neutrons with respect to time of flight (the marker frequency is 100 MHz).

operation of the target we used a diagnostic complex which revealed the characteristics of the laser light, the x radiation, and the corpuscular radiation.

Figure 1a shows a typical oscilloscope trace of the hard x radiation ($h\nu \simeq 0.1$ MeV; the first pulse on the trace) which arises in the cavity as the laser light strikes its wall and also the neutron emission (the second pulse). The position of the neutron pulse with respect to the x-ray pulse agrees within 1 ns with the calculated arrival time of 14.1-MeV neutrons at the scintillation detector. The neutron spectrum (Fig. 1b) shows that the neutrons are generated in a DT plasma whose particles have an average kinetic energy of about 6 keV. The total number of neutrons found from this trace is $(3.2 \pm 0.4) \times 10^9$ and agrees well with the results of integral measurements based on copper and indium activation. In this series of experiments, the neutron yield for the various target constructions varied over the range $(0.9–6) \times 10^9$, depending on the specific energy deposition in the microballoon holding the gaseous DT mixture.

The energy deposition in the microballoon was found from the shell collapse time, which was detected by means of a time sweep of the x-ray emission at x-ray energies $h\nu \geqslant 4$ keV (Fig. 2). The average shell velocity found from Fig. 2 is $\simeq 3 \times 10^7$ cm/s.

The high uniformity of the x-ray bombardment of the microballoon is illustrated by Fig. 3, on which we can see the initial position of the shell and the emission from the plasma at the end of the collapse stage. In this experiment the volume compression of the microballoon was about 60 (the final density of the DT mixture was $\leqslant 0.2$ g/cm^3.

In summary, these experiments demonstrate that it is possible to produce hot, dense plasmas and to make effective use of their properties during indirect bombardment of a microballoon containing gaseous DT at the Iskra-5 laser installation.

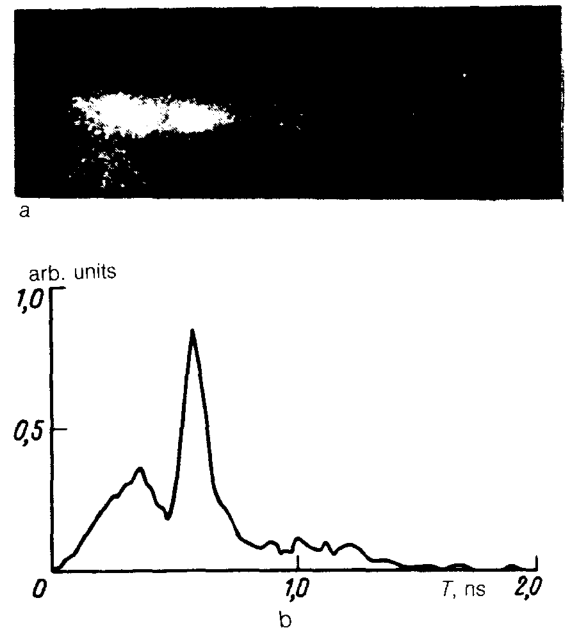

FIG. 2. Time sweep of the x-ray emission from the microballoon ($h\nu \geqslant 4$ keV, time resolution of 30 ps). a—Streak photograph of the emission; b—shape of the x-ray pulse.

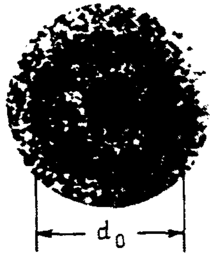

FIG. 3. x-ray image of a microballoon containing a gaseous DT mixture ($h\nu \simeq 4.5$ keV).

[1] V. I. Annenkov, V. A. Bagretsov, V. G. Bezugdov *et al.*, Kvant. Elektron. (Moscow) **18**, 536 (1991) [Sov. J. Quantum Electron. **21**, 487 (1991)].
[2] A. V. Bessarab, V. A. Gaïdash, G. V. Dolgoleva et al, Zh. Eksp. Teor. Fiz. **102**, 1800 (1992) [Sov. Phys. JETP **75**, 970 (1992)].
[3] J. D. Kilkenny *et al.*, Plasma Phys. **3**, 29 (1989).
[4] S. Nakai *et al.*, Nucl. Fusion **30**, 1779 (1990).
[5] M. De Croisette, *Scientific Readings of Zababakhin* (*Abstracts*) (Chelyabinsk, 1992).

Translated by D. Parsons