These results offer evidence that the plasma expansion in the magnetic field is not spherical, but proceeds mainly in the field direction. This is expected to slow down the cooling of the plasma [6].

The noticeable influence exerted by the magnetic field in our experiments on the spark geometry allows us to make an independent estimate of the lower limit of the plasma temperature. The characteristic parameters of the spark are in our experiment $r = 0.1$ cm and $\tau = 3 \times 10^{-7}$ sec, from which it follows that the plasma temperature exceeds 6×10^5 °K.

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INJECTION OF LASER PLASMA INTO A STELLARATOR

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The suggestion of using the plasma produced by interaction of laser radiation with a solid target to fill magnetic traps was advanced long ago [1]. The appreciable rise in laser power had made this idea particularly promising, since it makes it possible to obtain a dense plasma with high ion temperature (total number of particles $\sim 10^{17}$, $T_i \sim 5 \times 10^2$ eV). The use of a laser plasma to fill toroidal magnetic traps, particularly stellarators [4], is of great interest, since it makes it possible to obtain a dense plasma with hot ions. The low electron temperature (on the order of 1 eV) is not a major shortcoming, since the heating of electrons only is a relatively simple problem.

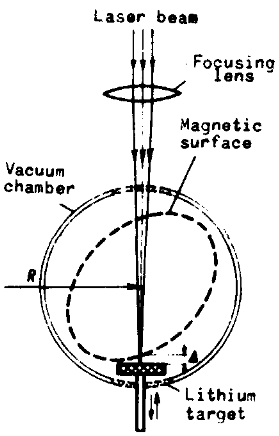

Fig. 1. Diagram of experiment.

We present here the results of a study of the main laws governing the parameters of a captured laser plasma injected into the closed magnetic trap TOR-1 [2], and demonstrate the high efficiency of the capture.

The TOR-1 setup is a stellarator with a two-mode helical field. The major radius of the toroidal vacuum chamber is 60 cm, and its cross-section radius is 5 cm. The experiments were performed at a turn conversion angle 0.72π, and the magnetic field intensity ranged from 3 to 10 kG.

The experimental setup is shown in Fig. 1. A neodymium-laser beam (pulse duration 3×10^{-8} sec, energy 0.5 - 5 J) was focused with the aid of a lens

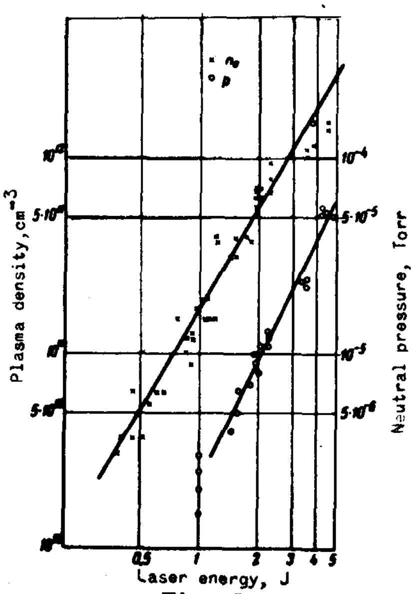

Fig. 2

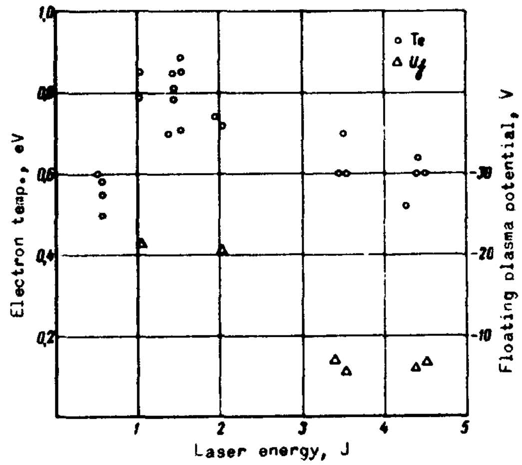

Fig. 3

Fig. 2. Dependence of the plasma density (n) at 300 - 500 μsec after injection and of the neutral-particle pressure (p) on the laser energy (Q), H = 6.7 kOe.

Fig. 3. Dependence of the electron temperature (T_e) and of the floating potential (U_f), measured at 1 msec after the injection on the laser energy (Q), H = 6.7 kOe.

on a massive target. The target could be moved relative to the boundary magnetic surface. The target was a lithium disk of 24 mm diameter and 5 mm thickness. The choice of lithium was governed by the fact that it has the smallest atomic weight of all the solid substances and accordingly the smallest ion Larmor radius. In addition, the large efficiency of trapping of lithium atoms by collision with the wall of the vacuum chamber should rid the plasma of the neutral particles produced both by the interaction between the laser and the target and by the neutralization of the decaying plasma.

We investigated the dependence of the density, electron temperature, the potential of the captured plasma, and the pressure on the laser energy, the dimensions of the focal spot, the position of the target, and the magnetic field intensity.

The plasma density was measured with the aid of a microwave Fabry-Perot interferometer [3]. Figure 2 shows the dependence of the density of the plasma captured in the trap on the laser-pulse energy Q at 300 - 500 μsec after injection. The plasma density increases with energy of the laser pulse approximately quadratically, reaching at 5 J a value $\sim 2 \times 10^{12}$ cm^{-3}. The total volume of the plasma in the trap is $\sim 10^4$ cm^3, i.e., the number of particles captured in the trap reaches 2×10^{16}. If it is recognized that the total number of charged particles in the laser plasmoid does not exceed 10^{17}, this points to a high capture efficiency.

The electron temperature T_e was determined from the conductivity of the plasma column, measured with the sounding current excited in the plasma. Figure 3 shows the dependence of T_e on Q at 1 msec after injection. The electron temperature is of the order of 1 eV and depends little on the laser-radiation energy. The floating potential U_f of the plasma was measured with a heated

Langmuir probe. The plasma potential is negative, pointing to a predominant outflow of the ions. At a density $\sim 10^{11}$ cm^{-3} we have $U_f \simeq 20 - 25$ V, and with increasing laser energy the potential decreases by a factor 3 - 4 (Fig. 3). Measurements have shown that the steady-state gas pressure increases with increasing laser-pulse energy (see Fig. 2), reaching 5×10^{-5} Torr at 5 J (the initial pressure in the chamber is $\sim 5 \times 10^{-7}$ Torr). It can be assumed that the main source of the neutral particles is the gas absorbed by the walls of the vacuum chamber. A very important characteristic of the captured plasma is the ion temperature, but no direct measurements of the ion temperature have been performed as yet. An estimate of the ion energy, based on measurement of the plasma stream velocity during the filling of the trap, has shown that the translational energy is of the order of several hundred eV and increases with the laser energy. Experiments were performed on the study of the connection between the density of the captured plasma and the dimension of the focal point on the target (0.3 - 3 mm), the position of the target relative to the boundary magnetic surface (±10 mm), and the magnetic field intensity (3 - 10 kOe). None of these factors influence greatly the plasma parameters; for example, when the magnetic field is changed by a factor 3 - 3.5 the captured-plasma density changes by a factor 2 - 2.5.

Thus, we have demonstrated the possibility of using a laser plasma to fill a toroidal magnetic trap, the high capture efficiency, and the possibility of varying the parameters of the captured plasma in a wide range.

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INFLUENCE ON CORRUGATION OF THE MAGNETIC FIELD ON THE EXPANSION AND COOLING OF A DENSE PLASMA

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As one of the variants of the thermonuclear reactor of the future, we consider a direct system with dense plasma[1]).

It is assumed that the radial thermal conductivity of the plasma is suppressed by a longitudinal magnetic field, and the radial pressure of the plasma is balanced either by the pressure of the magnetic field or by the pressure of the walls.

If the plasma is produced in the center of the installation, without contact with the ends, then the time of its cooling is determined by the velocity of the free expansion along the magnetic field:

$$t_1 \sim L(M/T)^{1/2}, \tag{1}$$

[1])Dense in the sense that the mean free path of the particles λ is small compared with the length of the apparatus L.