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ACCELERATION OF LASER-PLASMA IONS IN A CYCLOTRON

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1. Experiments aimed at registering multiply charged ions in a laser plasma [1, 2] and at investigating such ion-emission characteristics as the maximum ionization multiplicity, the energy and spatial distribution of the ions, and the number of ions of given charge, have shown [3 - 5] that a laser plasma is an effective source of multiple charged ions (MCI) and can be used in accelerator injectors.

We report here experimental realization of acceleration of D^+ ions of a laser plasma in a cyclotron. We used internal ion injection, i.e., the laser plasma was produced in a magnetic field of the cyclotron inside the accelerating gap.

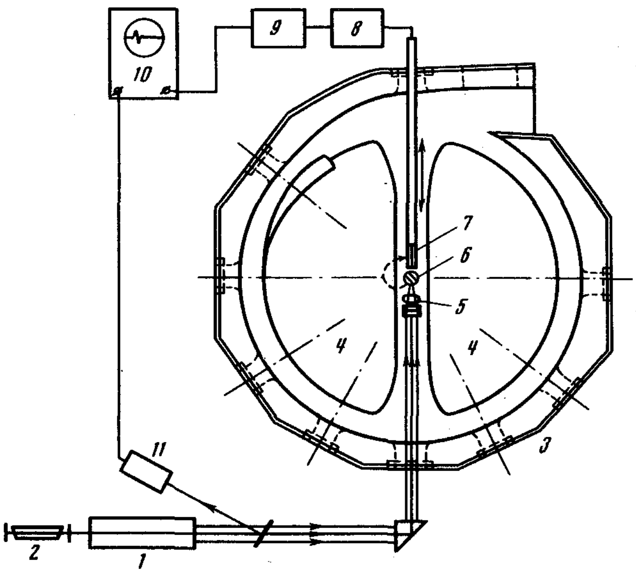

Fig. 1. Experimental setup: 1 - neodymium laser, 2 - adjusting He-Ne laser, 3 - cyclotron chamber, 4 - dees, 5 - optical system, 6 - target, 7 - probe with collectors, 8, 9 - amplifiers, 10 - oscilloscope, 11 - photocell.

2. The experimental setup is illustrated in Fig. 1. The laser plasma was produced by focusing the radiation of a neodymium laser (1) on the surface of a TiD sample (6) placed between the cyclotron dees (4). The normal to the surface of the flat sample was directed horizontal along the accelerating gap between the dees.

The radiation of the neodymium laser, which operated in the giant pulse regime ($P = 50$ MW, $\tau = 2$ msec), was introduced through a special window in the cyclotron chamber and passed through an optical system (5) consisting of a rotating prism and a lens, ensuring incidence of the focused laser radiation at 45° to the sample surface. In order not to block the ion beam, the optical system was located below the dees.

The accelerated ions were registered by a screened metallic collector having a receiving area 8 × 4 mm. A passive collector, of identical construction as the working collector but protected against the incidence of ions, was placed on the same screen. Since the noise induced in both collectors was the same, the subsequent differential registration has made it possible to separate reliably the ion-current signal.

The collectors were placed on the end of a probe that could be moved radially in the chamber between the dees. The signal from the collectors was fed to an oscilloscope with memory. The oscilloscope sweep was triggered in synchronism with the start of the laser pulse.

3. As a result of the experiments we registered a flux of accelerated deuterium ions in the cyclotron. At a radius $R = 13$ cm, the deuteron current was 15 μA at a deuteron energy $E \sim 750$ keV. The duration of the pulse of accelerated deuterons (per laser flash) was ∿1.5 μsec at half-height of the pulse (Fig. 2a).

The amplitude of the ion current depended on the magnetic field in resonant fashion. The resonant value of the magnetic field $H = 14$ kOe corresponded to acceleration of the D^+ ions at a RF field frequency $f = 10.2$ MHz. If the magnetic field deviated from the resonant value, the ion-current signal

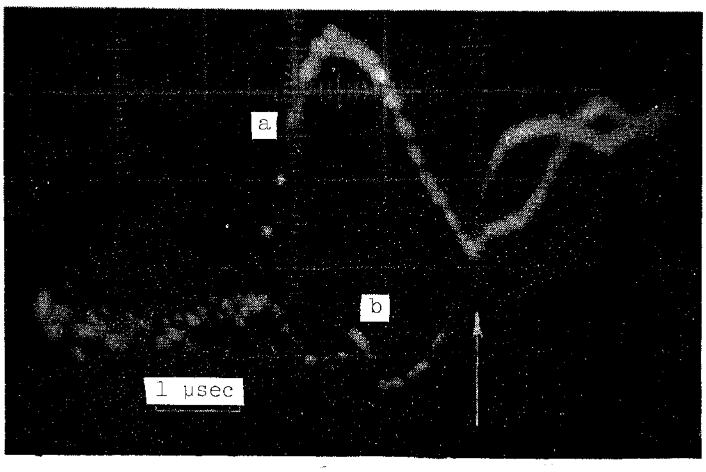

Fig. 2

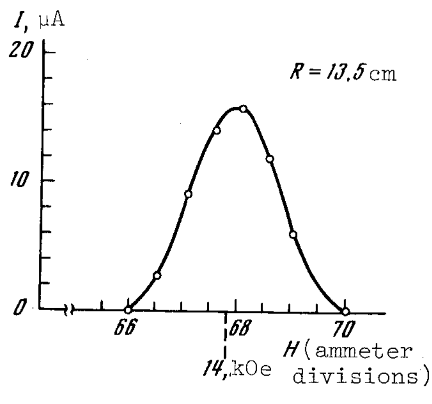

Fig. 3

Fig. 2. Oscillograms of ion current. The arrows indicates the termination of the D^+-ion current. The remainder of the oscillograms corresponds to the impurity ions. a) Resonant magnetic field, $H = 68$ (ammeter scale divisions), b) magnetic field deviates from resonance ($H = 65$).

Fig. 3. Ion current vs. magnetic field.

decreased sharply (Fig. 2b). The dependence of the ion current on the magnetic field is shown in Fig. 3.

At a fixed resonant value of H, we measured the dependence of the deuteron current on the amplitude of the HF field. We investigated also the dependence of the deuteron current on the laser emission power.

With decreasing registration radius, the deuteron-beam current reached 200 μA at a radius R = 5 cm. The resonant dependence of the signal on H becomes less steep. The time of appearance of the ion signal relative to the start of the oscilloscope sweep is determined by the distance from the collector to the target and by the amplitude of the HF field.

These facts show that we have realized a regime in which D^+ ions obtained in a laser plasma are accelerated.

4. Since the laser operated in a single-pulse regime, it was difficult to register the signal (to extract the beam) at distances more than 15 cm from the target. The use of frequency lasers will increase the beam intensity and will also yield beam energies higher than 1 MeV.

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PHOTOINDUCED MUTUAL TRANSFORMATION OF CENTERS RESPONSIBLE FOR "MULTIPLETNESS" IN THE SHPOL'SKII EFFECT

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Personov and Korotaev [1] observed reversible changes in quasiline spectra of protoporphyrine exposed to radiation from a helium-neon laser (λ = 6328 Å), i.e., in the region of the main "multiplet") at 4.2°K. The complex character of the "multiplet" for this compound makes the interpretation of the experimental data difficult. At the same time, it is obvious that investigations of similar changes in the "multiplet" structure are essential for the solution of the problem of "multipletness" in the Shpol'skii effect. Owing to a fortunate choice of the object of investigation - tetrabenzoporhin (TBP) - which has a simple "doublet" structure of the quasiline spectra, we have obtained experimental data that explain the nature of the phototransformations of the centers in Shpol'skii crystal matrices.