10-HZ-INJECTION AT A LASER FOCUS OF TARGETS ACCELERATED INTO SPRING-HTSC-MAGLEV SYSTEM

E.R. KORESHEVA, I.V. ALEKSANDROVA, M.N. AGAPOV, A.A. AKUNETS, A.I. NIKITENKO

Lebedev Physical Institute, Russian Academy of Sciences, Moscow, 119991 Russia

Email: koreshevaer@lebedev.ru

At present, in operating inertial confinement fusion (ICF) facilities, laser irradiation is carried out on a cryogenic fuel target (CFT), previously fixed in the irradiation zone using a special suspension (thread, capillary, cone, film, etc., see, for example, [1]). The presence of a material contact between the suspension and the CFT does not allow the fundamental requirement of ICF to be realized: spherically symmetric irradiation of CFT. The problem solution lies in the implementation of CFT delivery by injection.

Innovative technologies on creation of a HTSC-MAGLEV accelerator designed for injection delivery of CFTs using a levitating HTSC carrier are being intensively developed at the Lebedev Physical Institute [2, 3]. The research is based on the phenomenon of quantum levitation of a high-temperature superconductor (HTSC) in a gradient magnetic field. The acceleration and deceleration processes of the levitating HTSC carrier are carried out by mechanical or electromagnetic action.

In this work, the acceleration of the levitating HTSC carrier in the HTSC-MAGLEV system was provided by the mechanical action of a spring mechanism. The setup includes: three HTSC carriers (carrier #1: 25x4x4 mm, weight 0.97 g; carrier #2: 37x4x4 mm, 0.29 g; carrier #3: 50x4x4 mm, 0.55 g), and a HTSC-MAGLEV accelerator, including a spring mechanism (spring – □ 8 mm, height 15 mm – maximum, 4 mm – in a compressed state, 4 turns), a magnetic rail (size 360x24x5 mm, $\Delta B = 0.33$ T), two HTSC carrier speed sensors and a mechanical brake. The diagram and general view the experimental setup are shown in Fig. 1.

The following results were obtained in the experiments:

— The velocity of the HTSC carrier in the MAGLEV accelerator was: 2.8–3.6 m/s (carrier #1), 3.0–7.1 m/s (carriers #2 and #3).

— The acceleration of the HTSC carrier containing one surrogate target and mechanical braking of the HTSC carrier with subsequent target injection were experimentally demonstrated.

— The acceleration of the HTSC carrier containing two surrogate targets with subsequent braking and injection of targets was recorded. The time interval between the injection of two targets was 100 ms, which corresponds to an injection frequency of 10 Hz. Observations were carried out in the light of a laser semiconductor diode reflected from the surface of the targets (λ = 650 nm). The results of the experiment are shown in Fig. 2.

A theoretical assessment of the required CTM injection rate for target chambers of various dimensions with a wall temperature of T=300 K was performed. The data obtained showed that for a chamber radius of 1 m, the required CTM injection rate is 3.2–7.7 m/s at target injection angles into the chamber of 45°– 5°, respectively. Assessments performed for the chamber of the Harpoon laser facility operating at the Lebedev Physical Institute (distance to the chamber center is 15 cm) showed that the required CTM injection rate is from 1.2 m/s (injection angle of 45^0) to 3 m/s (injection angle of 5^0).

Thus, for the first time in the world, 10-Hz-injection of surrogate targets was carried out using the HTSC-MAGLEV system created at the Lebedev Physical Institute. The results obtained allow planning unique experiments on spherically symmetric laser irradiation of CTMs injected into the target chamber of operating ICF installations.

ACKNOWLEDGEMENTS

The work was performed within the framework of the State Assignment of the Lebedev Physical Institute (AAAA-A19-119083090043-0), and was supported by the IAEA (scientific project no. 24154).

REFERENCES

[1] KRITCHER, A.L., et al. Phys. Plasmas **31** (2024) 070502

[2] KORESHEVA, E.R., et al. Quantum Electronics **54** 3 (2024) 175

[3] ALEKSANDROVA, I.V., et al. Bull. Lebedev Phys. Inst. **50** 8 (2023) 332.

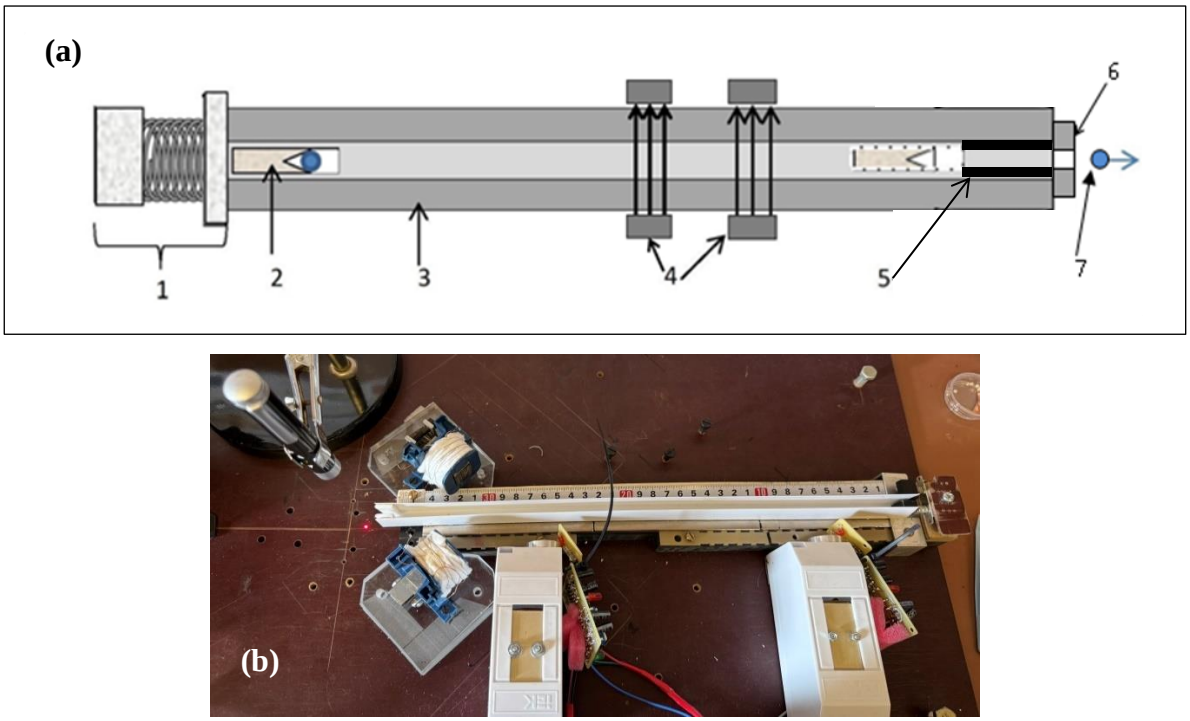

Fig. 1. Schematic (a) and general view (2) of the spring HTSC-MAGLEV accelerator.
1– Spring trigger mechanism, 2 – HTSC carrier with target, 3– magnetic track,4– HTSC carrier speed sensors, 5 and 6 – mechanical brake and injector nozzle, 7 – injected target

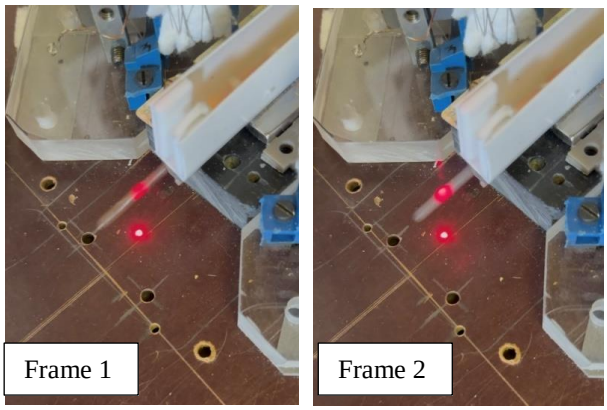

Fig. 2. Stop-frames of video recording of sequential injection of 2 surrogate targets (glass beads ∅ 3 mm).