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GENERATION OF RUNAWAY ELECTRONS DURING FORMATION OF PLASMA DIFFUSE JETS *)

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In our articles [1-3] we described red plasma diffuse jets (PDJs), which are laboratory analogues of columnar red sprites (CRS) [4]. PDJs consisted of streamers [3], and had emission spectra and plasma parameters similar to those recorded in CRSs. In addition, PDJs were initiated by plasma of a pulse-periodic capacitive discharge that has no contact with metal electrodes.

The purpose of this work is to show that, in a capacitive pulse-periodic discharge in low-pressure air, runaway electron beams (REBs) can be generated from plasma that has no contact with metal electrodes.

The studies were conducted on a modernized setup based on a quartz tube with external ring electrodes, previously used to study the properties of the PDJ, see articles [1-3]. In this work, an NPG-18/3500N generator with a higher amplitude of voltage pulses (12-18 kV) was used. In the experiments, the REB pulses, gap voltage and discharge current were measured, and the PDJ radiation spectra were recorded and their shape was photographed. A coaxial collector with a time resolution of up to 100 ps was used to record the REB current, with the help of which direct registration of the runaway electron beam current was performed.

With the NPG-18/3500N generator, the REB currents were obtained in wide ranges of air pressures and voltages. It was found that the REB amplitude increases with an increase in the voltage pulse repetition rate to 2 kHz. The maximum beam current amplitude was recorded with a delay of ≈ 5.6 ns relative to the voltage pulse maximum. This is due to the time it takes for electrons to fly from the near-electrode region, where they gain most of their energy, to the collector. The REB was recorded with the grounded ring electrode positioned between the high-voltage electrode and the grounded collector, which was 14 cm away from the grounded ring electrode. Based on this, it can be concluded that fast electrons receive their main acceleration near the high-voltage ring electrode. Changing the position of the high-voltage ring electrode relative to the collector did not affect the beam current generation. When a 100-micron paper filter was installed behind the collector grid, the REB was not registered due to the relatively low energy of runaway electrons under these conditions.

The beam current pulse duration at half-height at an air pressure of 1 Torr was ≈ 3 ns, and its density was ≈ 8 mA/cm^2. The amplitude of the REB increased with the generator voltage and, taking into account the grid transparency, exceeded 25 mA at the receiving part of the collector, which had a diameter of 2 cm. It was found that under these conditions the REB precedes the PDJ front and is registered by the collector before its arrival. The results obtained can be used to study the properties of high-altitude discharges.

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References

[1]. Tarasenko V.F., Vinogradov N.P., Baksht E.Kh., D.A. Sorokin. J. Atmospheric Science Research, 2022, **5**(4), 26-36.
[2]. Sorokin D.A., Tarasenko V.F., Baksht E.Kh., Vinogradov N.P. Physics of Plasmas, 2023, **30**(8), 083515.
[3]. Tarasenko V.F., Baksht E.Kh., Panarin V.A., Vinogradov N.P. Plasma Physics Reports, 2023, **49**(6), 786-794.
[4]. Marskar R. Plasma Sources Sci. Technol., 2024, **33,** 025024.

*) abstracts of this report in Russian