Analysis of a complex space charge configuration formed in weakly magnetized diffusion plasma

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1. Introduction.

By applying a positive potential on an electrode immersed in a weakly magnetised diffusion plasma, a complex space charge configuration (CSCC) in form of a luminous firerod appears [1]. This CSCC consists of a positive nucleus (ion rich plasma) bordered by an electric double layer (DL) [2]. The appearance of the CSCC is determined by the electron-neutral impact excitations and ionizations, which appear because of the electron acceleration towards the electrode [2].

We present here a broad investigation of the appearance of such a structure by using Langmuir probes, as well as emissive probes. Measurements were made in pulsed regime and the electron energy distribution function (EEDF) was recorded at different times after the application of the step voltage on the electrode.

2. Experimental setup

Fig. 1 shows the experimental setup [3], which is a linear magnetized plasma device, 1.5 m long and 17 cm in diameter. The electrode immersed in plasma was a disc with 2 cm in diameter. A step signal, 100 µs was applied on this electrode by using a very fast field effect transistor switch. The switch is turned on and off by rectangular voltage pulses from the signal generator. These pulses are also used for triggering the digital oscilloscope and a boxcar average. Signals from the probe are sampled and averaged by the boxcar integrator. Output signals from the boxcar are digitized and stored into the computer for later analysis. Plasma is produced by an electrical discharge between the direct current heated tungsten filaments and the vessel wall, and diffuses toward the electrode. Primary electrons are accelerated by a discharge voltage $V_d = 50$ V, the discharge current being $I_d = 0.4$ A. The argon pressure was $p = 3 \times 10^{-4}$ Torr and the magnetic field $B = 0.02$ T. A one-side emissive probe, protected by a mica shield, was used in order to record current-voltage characteristics,
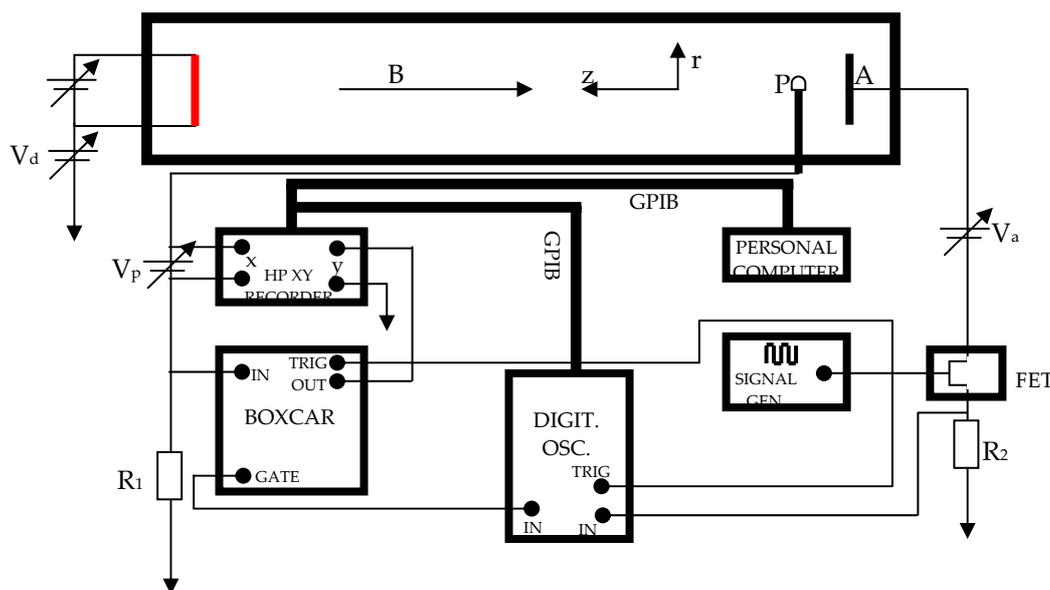
Fig. 1: Experimental set-up

being heated by a current I_h = 3.5 A. The measurements were made with different orientations of probe: toward and away from the electrode.

3.   Experimental results and discussions

The measurements were made at different times after applying the pulse signal on the electrode. For an orientation of the hot probe toward electrode, an additional positive current was obtained, approximately after 10µs, in good agreement with the results obtained by Gyergyek *et al.* [4]. For the orientation of the hot probe away from electrode, a gap in the ionic part of current-voltage characteristic was observed. These results are shown in Fig. 2. Fig. 3 shows the first derivatives of the cold probe characteristics, which are proportional with the electron energy distribution functions [5]. The probe was inserted into the firerod, on it axis, 0.35 cm in front of their frontal part, the voltage on the electrode being V_a = 40 V. On can observe that, immediately after the pulse onset, a fast electrons group appears in the EEDF. These electrons are those accelerated in the voltage across the double layer. Once the firerod is fully developed (after about 16 µs) this fast electrons group becomes dominant in the EEDF. The slow electron group disappears from the EEDF, being accelerated at high energy. These fast electrons produce electron-neutral impact ionizations, creating, in this way the charged particle needed for firerod existence.
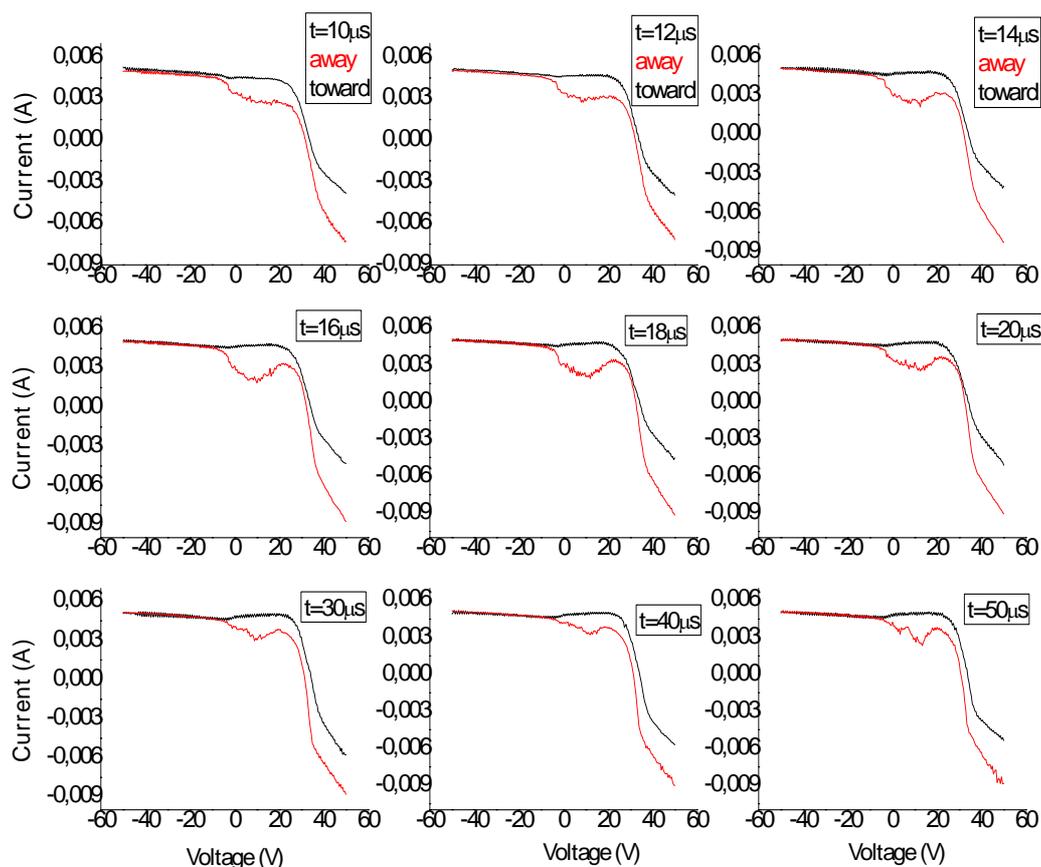
Fig. 2: I-V characteristics of the hot probe, with both orientations of the probe

4. Conclusions

 Cold and emissive probe measurements were used to investigate a firerod which appear in front of a positively biased electrode immersed in weakly magnetised plasma. The results prove the essential role of the double layer in maintaining the firerod structure.
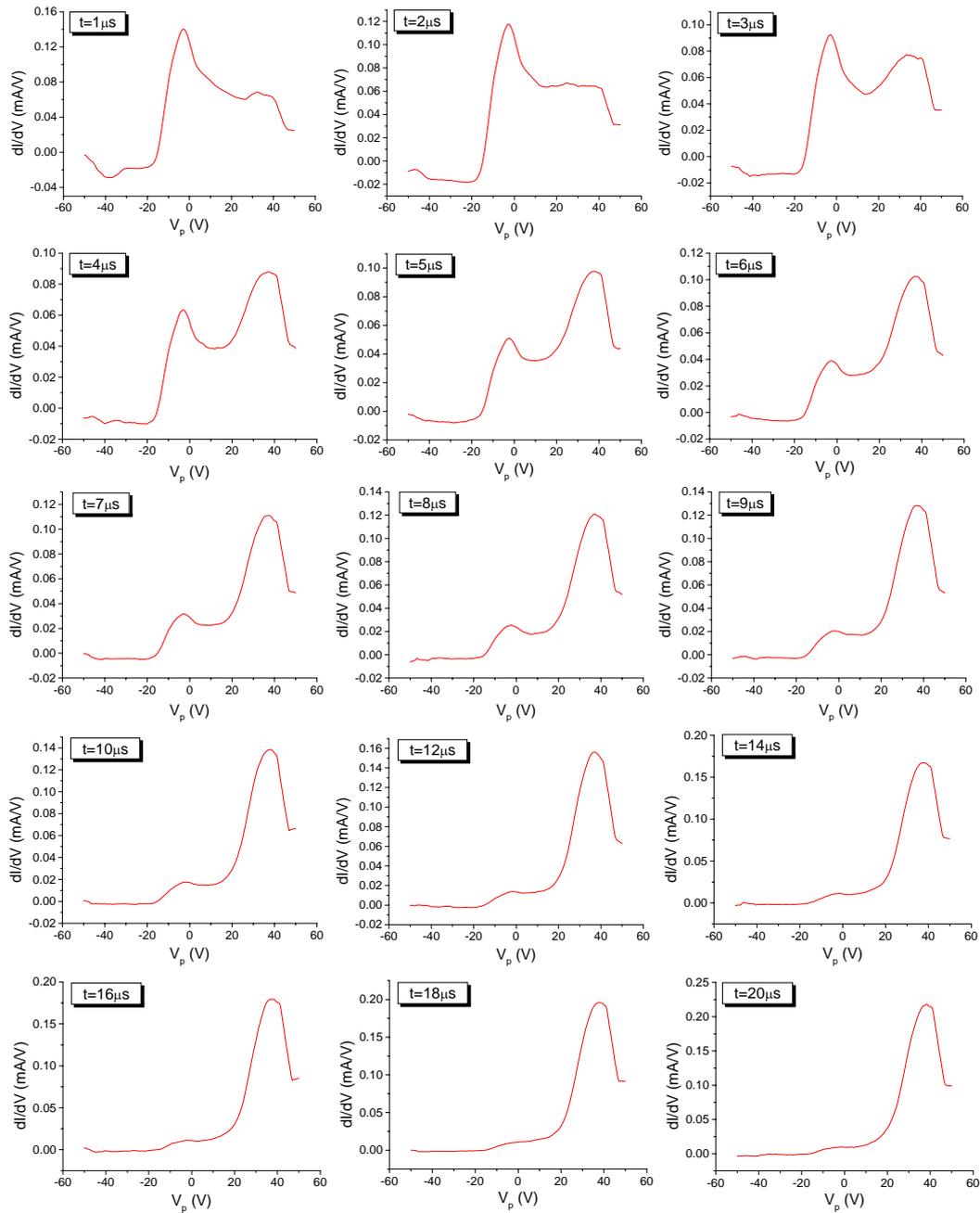
Acknowledgments

Figure 4: Distribution function from the characteristics of the cold probe

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