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ON THE INTERACTION BETWEEN COMPLEX SPACE CHARGE STRUCTURES IN PLASMA

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1. Introduction

When an electrode immersed into an equilibrium plasma is positively biased up to a threshold value, a complex space charge structure in form of an intense luminous, almost spherical plasma body appears in front of it. This structure consists of a positive nucleus (ion enriched plasma) confined by an electrical double layer [1]. In certain experimental conditions, a more complex structure can appear, in form of multiple concentric or non-concentric double layers [2,3]. In the case of the non-concentric multiple double layers, the experimental investigation of the interaction between the individual component double layers is difficult because of the common exciting electrode. This interaction seems to be responsible for the transition to chaos of the multiple double layers dynamics [4].

Here we report on the experimental results related to the interaction between two such complex space charge structures excited on two identical electrodes immersed in the same plasma. In this way, we can obtain a non-concentric multiple double layers structure by using a multiple electrodes geometry and we can investigate the interaction between the individual double layers.

2. Experimental results and discussion

The experiments were made in a plasma diode, schematically shown in Fig. 1. A discharge is fired between the hot filament (F in Fig. 1) and the grounded wall of chamber as anode. The plasma parameters, measured by mean of emissive and cold probes, were: $n_{pl} \cong 10^8$ cm^{-3}, electron temperature $T_e \cong 2$ eV for an argon pressure $p = 5\times10^{-3}$ mbar. In this diffusion plasma, two electrodes (E_1 and E_2 in Fig. 1) were immersed, being positively biased in respect to the plasma potential.

Two kinds of experiments were performed. In the first one, the positions of the electrodes were kept constant (with a distance of about 20 cm between the two electrodes), as well as the voltage applied on the first electrode (V_1 = 125 V), while the voltage applied on the second electrode was changed between 0 and 250 V. On the first electrode a double layer ini-

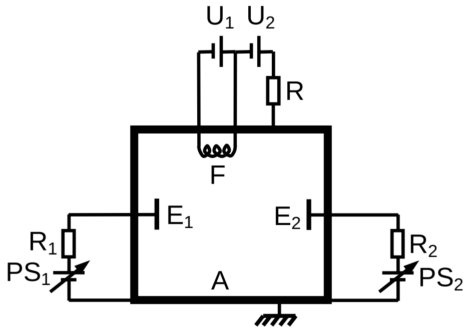

Fig. 1: Experimental setup (A – anode, F – filament, E_1,E_2 – supplementary electrodes, PS_1,PS_2 – power supplies

tially exists in dynamic state, the frequency of the oscillations being of about 3.2 kHz. In Fig. 2 the time series corresponding to the oscillations of the current collected by the two electrodes are shown, at different values of the voltage applied on the second electrode, were qualitative changes appear. When the voltage applied on the second electrode reach the value V_2 = 30 V, a double layer appears also on the second electrode, both structure oscillating with the same frequency of about 1.37 kHz (Fig. 2a). At the value V_2 = 69 V, the amplitude of the current oscillations through electrode E_2 increases about 50 times, the shape of both oscillations being also changed (Fig. 2b). By further increasing the voltage on E_2, the frequency of both oscillations increases (faster for the oscillations of the current through E_2), while the amplitude of the oscillations through E_2 slowly decreases (Fig. 3c). At the value V_2 = 171 V, the frequency of the current oscillations through E_2 reaches the value $f_2 \cong 7$ kHz (Fig. 3d). When the voltage on E_2 reaches the value V_2 = 175 V, both structures become stable, no oscillations of the current being recorded. This stable state remain unchanged until V_2 = 250 V.

In the second experiment the voltages on both electrodes are kept constant (V_1 = 59 V, V_2 = 39 V), only the distance between the electrodes being decreased from 25 to 2 cm. In Fig. 3 the oscillations of the current collected by the two electrodes are shown, for different values of the distance between electrodes. Initially, the double layer structures exist on the electrodes in stationary states, no oscillations of the current being recorded. When the distance between the electrodes reaches the value d = 24 cm, both structures transit in dynamic states, oscillations of the current through both electrodes being recorded (Fig. 3a). At d = 17 cm a period doubling bifurcation appears in the oscillations of the current through E_2, while the amplitude of the current oscillations through E_1 increased with one order of magnitude (Fig. 3b). For d = 10 cm a new period doubling bifurcation appears in the oscillations of the current collected by E_2 (Fig. 3c). When the distance between the two electrodes reaches the value d = 4 cm, the oscillations of the current through the two electrodes become correlated, with the same frequency, but different amplitudes (Fig. 3d).

In dynamic state, the double layer structure periodically disrupts and re-appears, bunches of particles (positive ions and electrons) being released into the surrounding plasma. These particle fluxes can be responsible for the interaction between the two structures, giving rise to changes in the oscillation regimes.

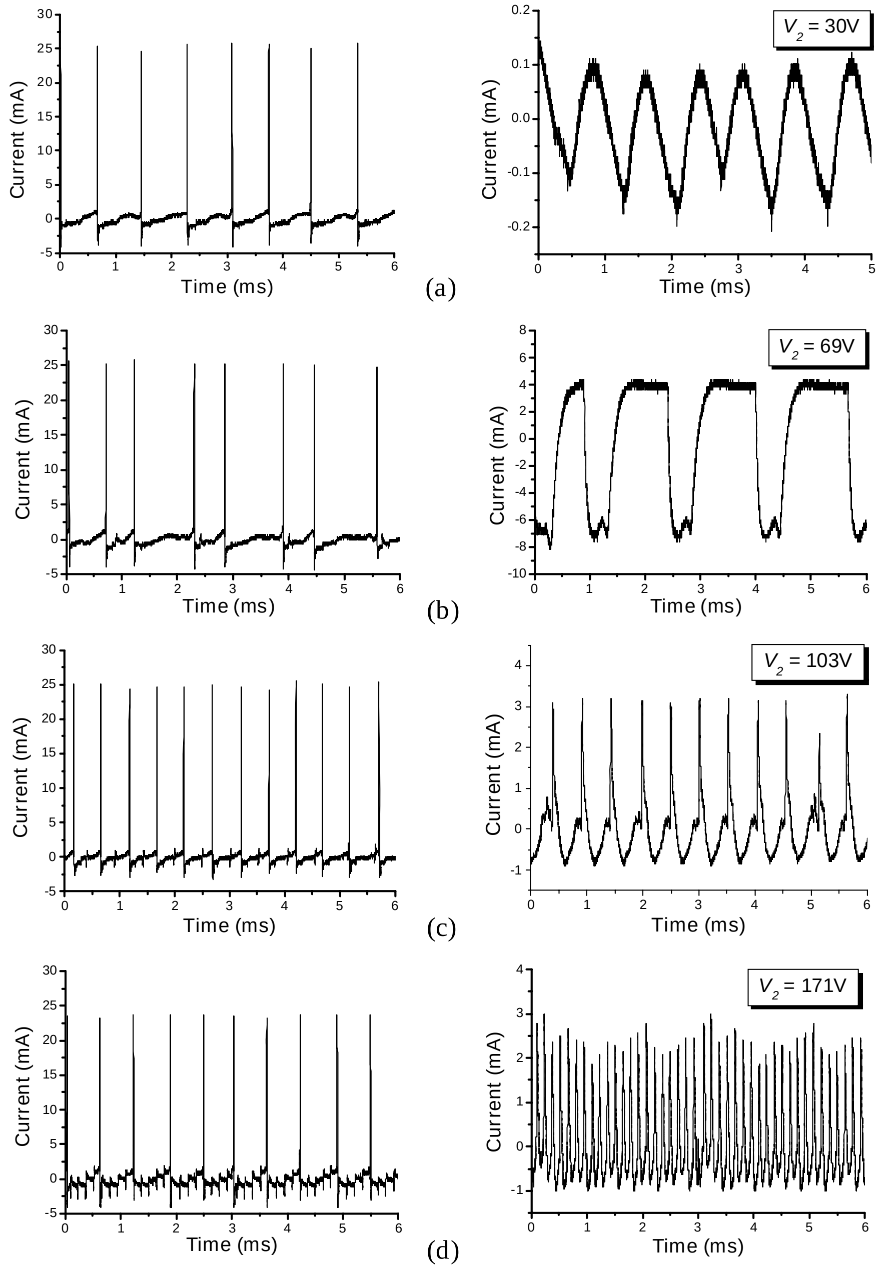

Fig. 2: Oscillations of the current collected by E_1 (left column) and E_2 (right column), recorded for different values of the voltage applied on E_2

Conclusion

Experimental results are presented showing a strong interaction between two double layer structures obtained on two different positively biased electrodes, the structure dynamics being reciprocally affected by means of the particle fluxes released during the structures disruptions.

Acknowledgments

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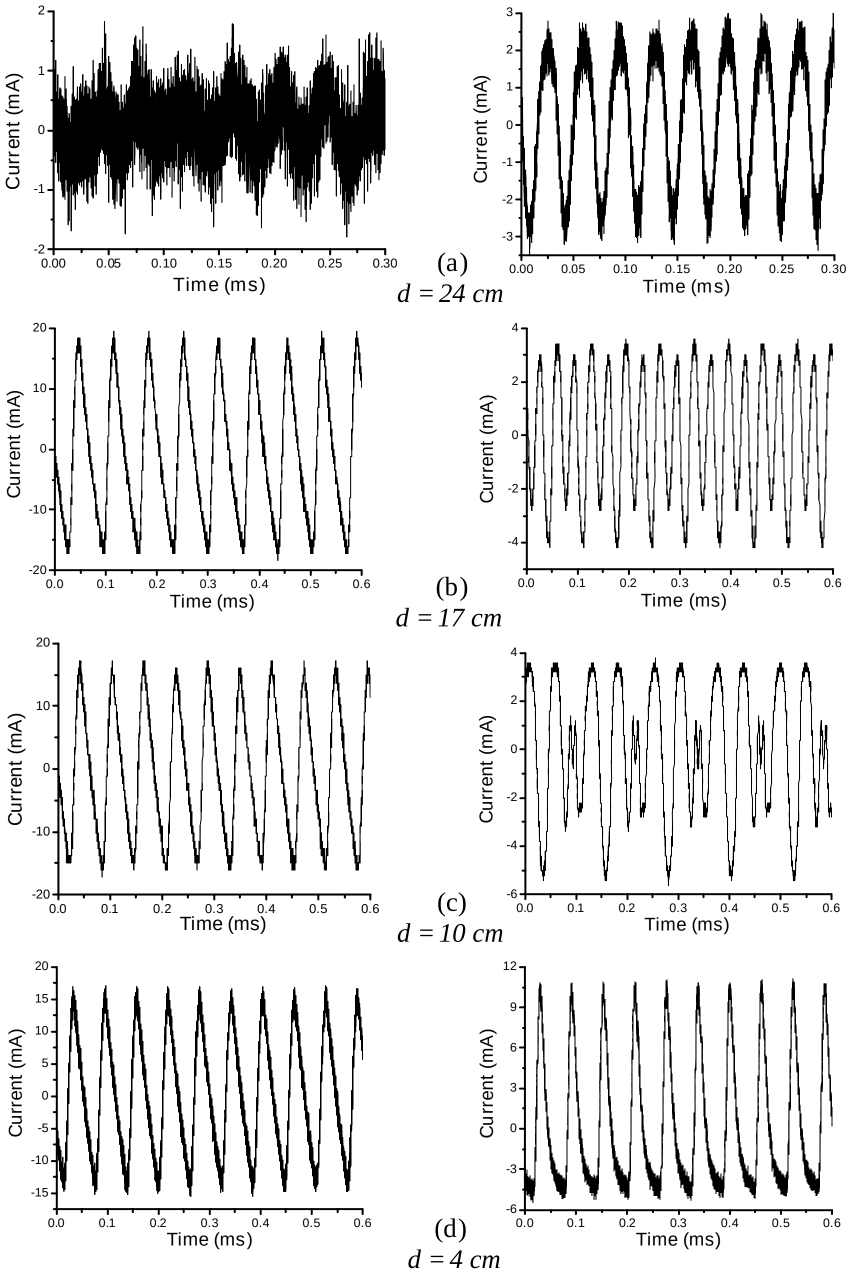

Fig. 3: Oscillations of the current collected by E_1 (left column) and E_2 (right column), recorded for different values of the distance between the two electrodes

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