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Study of variation of hysteresis effects in self–excited amplitudes of a coaxial DC electrode system

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The paper analyzes changes in behaviour of self-excited oscillations resulting from extended plasma exposure in coaxial DC discharge plasma having a central powered anode. The role of the system asymmetry seems to play a role in triggering the oscillations. These oscillations are seen to undergo hysteresis effects with discharge current (I_d), showing a characteristic difference in the hysteresis shape as the system ages with plasma exposure. The shape change is from a hysteresis, with negligible amplitude shift post hysteresis (Type H4: bump-shaped), to a more generally observed one having a noticeable amplitude shift (Type H1: S shaped). Analysis tools such as phase maps, return maps, recurrence plots are used to characterize the variation of the observed changes in the oscillations and attempt to unravel the underlying physical mechanism to explain it.

1. Introduction

Observations of order-to-chaos-to-order transitions in the self-excited oscillations of plasma experiments have been reported [1, 2] earlier. In a study by Kumar *et. al.* [1], the associated order-to-chaos-to-order transitions have been correlated to a hysteresis in the amplitude of the floating potential fluctuations (V_f).

2. Experimental Setup

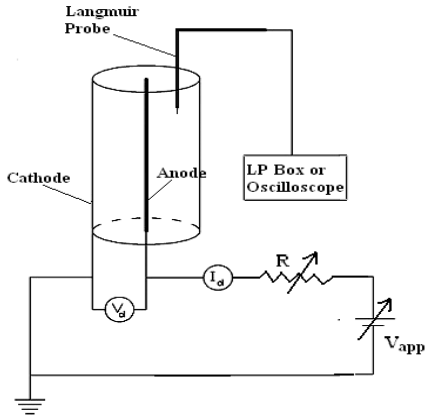

Fig 1: Schematic setup of coaxial DC plasma system

Experiments were carried out in a coaxial DC electrode (central anode diameter = 1.5 mm; outer cathode inner diameter = 48 mm) discharge system (Fig 1). A Langmuir probe, as seen in Fig 1, is used to measure the self-excited V_f oscillations.

3. Results and Discussions

Under certain operating conditions, hysteresis is observed in V_f amplitudes as a function of the discharge current (I_d) [1]. This amplitude hysteresis effect is observed between two Negative Differential Resistance (NDR) regions of the discharge characteristics (discharge current, I_d vs discharge voltage, V_d), which is also seen to undergo a hysteresis effect.

With plasma conditioning of several days one observes a flip in the forward-reversal paths of the I_d-V_d hysteresis. The plasma potential (V_p) is seen to be lower in the conditioned electrode discharges by about 30 V - 40 V. However, the more significant effect observed is modification of the behaviour of the self-excited oscillations also with the hysteresis flip in the I_d-V_d characteristics. For convenience, the unconditioned electrode is termed UE and the conditioned one is termed CE.

In the UE case, the hysteresis in the self-excited oscillations is to trigger higher amplitude oscillations in the forward path over a small range of I_d, reverting back to lower amplitudes at higher I_d (H1-type [3] or bump-shaped). However, in the CE case, the fluctuations show a characteristic change of state at higher I_d, *viz.*, a transition from low amplitude, high frequency oscillations to large amplitude, low frequency oscillations (H4-type [3] or S-shaped).

This abstract will present characteristic features of the variations in the two discharge cases using nonlinear dynamical analysis tools.

3. References

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