Experimental transition to chaos in low-temperature plasma

Dan-Gheorghe Dimitriu

Faculty of Physics, Alexandru Ioan Cuza University, 11 Carol I Blvd., RO-700506 Iasi, Romania
dimitriu@uaic.ro

Experimental results are reported on the transition to chaos in plasma by way of two scenarios: type I intermittency and cascade of spatio-temporal sub-harmonics generations, respectively. Both of these scenarios develop in connection with the generation and dynamics of patterns in plasma, in form of simple or multiple concentric fireballs.

It is well known that a very luminous, almost spherical structure (fireball) appears in front of a positively biased electrode immersed into low-temperature plasma up to a threshold value of the potential applied on the electrode. Up to a second threshold value of the potential applied on the electrode, this structure passes into a dynamic state, in which the double layer at its border periodically disrupts and re-aggregates. In certain experimental conditions, regular oscillations interrupted by random bursts were observed in the time series of the current collected by the electrode. By increasing the voltage applied on the electrode, the random bursts appear more frequently, the final state of plasma being a chaotic one. By applying the modern methods of the nonlinear dynamics, we identified a scenario of transition to chaos by type-I intermittencies. The recorded time series were also analyzed by recurrence plot quantification.

In certain experimental conditions, a more complex pattern appears in front of electrode, in form of multiple concentric fireballs (like an onion shape). By gradually increasing the voltage applied on the electrode, we have observed that each new luminous sheet appears simultaneously with the appearance of a new sub-harmonic in the power spectrum of the complex structure dynamics. After a cascade of such sub-harmonics generation (both spatial and temporal ones), the final state of the plasma system is a chaotic one. This seems to be a new scenario of transition to chaos, being different from quasi-periodic or Feigenbaum scenarios. A further experimental and theoretical analysis of this new scenario of transition to chaos will be necessary.

All experimental data were analyzed by the methods of the nonlinear dynamics, including the reconstruction of the states space by time delay method and recurrence plot quantification.