ABSTRACT

Systems far from equilibrium governed by nonlinear effects attract the attention of many researchers in different fields of science, such as biology, chemistry, and physics. In particular, it is the formation and selection of macroscopic spatio-temporal patterns and fundamental questions concerning the nature and development of turbulence that may be explained by non-linearties occurring in deterministic equations describing dissipative systems.

The main object of this work is the positive column of a dc neon glow discharge. The positive column is an excellent region for the study of non-linearity plasma system because it is non-isothermal plasma far from equilibrium state.

The purpose of this work is to contribute to the understanding of the nonlinear non- isothermal plasma by using both theoretical and experimental methods. Also a comparison of the experimentally observed space-time dynamics of the positive column with model calculations by means of more selected methods of the non-linear dynamics is discussed.

To investigate the temporal plasma (the time series analysis), one calculate the following:

- Power spectrum density (PSD),
- False Nearest Neighbor (FNN),
- Autocorrelation function (ACF),
- Lyapunov exponents, and
- Correlation dimension.

For Spatio-temporal plasma analysis, one evaluates;

- Biorthogonal decomposition (BOD Model),
- The simulation model (Complex Ginzburg- Landau equation)

For time series data (temporal plasma), an experiment was performed in a sealed cylindrical discharge tube (Pyrex glass) that was filled with pure neon gas at a pressure of P= 3.4 Torr. The tube has an internal radius of r=2 cm and the two electrodes (one cold hollow cathode and the other plane anode) were spaced at a distance of L 70 cm. Current feedback through the external circuit leads to ionization wave resulting in light intensity fluctuations that can be easily detected by photodiodes.

From the time series analysis we obtained the following results;

- We could distinguish different states of temporal plasma, periodic state, quasi-periodic state, chaotic state and strange non-chaotic state.
- The dynamic behaviour of plasma is found theoretically and experimentally, sensitive to initial conditions, which is mainly in the present work, the discharge current.
- The correlation dimension for chaotic system is found to be non-integer value but for periodic system is found to be integer value.
- The estimation of an attractor's dimension and Lyapunov exponents not only provides an indication of chaos, but also gives useful information about the properties of the underlying system, such as the degree of freedom and level of complexity.
- The value of correlation dimension is observed to depend on the sampling rate of the data. For the cathode analysis, the influence of sampling rate is not obvious because most of the analysis give a periodic attractor or

quasi-periodic attractor. It has a little influence, which is clear in the sampling currents I=51.9 mA and I=54.9 mA.

For space-time data also an experiment was performed in cylindrical dc glow discharge tube with r =1 cm, L=60 cm and I< 60 mA, (pure neon, P=3.1 Torr). Coherent ionization waves can be observed which represent discrete longitudinal spatial eigen modes. A fast CCD (charge coupled device) camera was employed for wave detection; the modulation of the light intensity.

For space-time analysis we can conclude that:

- We could distinguish three states; a phase turbulence state, a amplitude turbulence state and a regular state.
- It is found that, the instability state of space-time plasma for the two irregular states comes from the non-linear behaviour of the spatial wave-wave interaction.
- The theoretical simulation results give a good agreement comparing with the numerical results for both space-time data and time series data.

Finally, the simulation results of amplitude equation are in good agreement with the experimental space-time data.