# CHAPTER 6
# CONCLUSION

The nonlinear behaviour of the non-isothermal plasma through experimental and theoretical analysis is investigated. The main conclusions obtained from the experimental data and theoretical analyses are given.

## EXPERIMENTAL RESULTS

Two techniques were used for plasma investigation depending on the type of experimental data. Time series technique is a reliable tool for the study of complicated dynamics from measurements. For low pressure -low temperature plasma, time series analysis gives good results for temporal plasma. But for space-time plasma, the BOD method, which is the second technique, is found to be good for the complete analysis.

The main conclusions drawn from the experimental time series can be summarized as follows:

- We could distinguish different states of temporal plasma, periodic state, quasi-periodic state, chaotic state and strange non-chaotic state.
- The information about the state of plasma is found to sensitive to the quality and quantity of the experimental data.
- The dynamic behaviour of plasma is found theoretically and experimentally, sensitive to initial conditions that, 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.

- A low-dimension strange attractor is found to indicate that the plasma system should be described by a set of autonomous differential equations with at least three independent variables.
- 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. It is clear that the numerical analysis needs a large enough data to make a clear complete analysis.
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- The information about the state of plasma is sensitive to the quality and quantity of the data.
- The dynamic behaviour of plasma is sensitive to initial condition that, in this work, is the initial current.
- If the value of the correlation dimension is fractal, it indicates a chaotic attractor, but if it has an integer value, it indicates a periodic attractor.

## THEORETICAL SIMULATION RESULTS

For a complete analysis of space-time plasma, the BD is optimal in the sense that it captures the most energy possible in a given number of linear wave modes. This model is used for both experimental data and simulation results. The qualitative description of the wave phenomena by means of amplitude equations seems to be a good model to understand most of the nonlinear properties near the bifurcation point. The results of the present work give rise to the transition from the stability state (periodic state) to the instability region.

From the simulation results it can be concluded that:

- Exchanging bifurcation parameter (initial discharge current), we could distinguish three states; a phase turbulence state, a amplitude turbulence state and a regular state.
- The BOD (numerical model) analysis is cleared that the two different irregular states are consisting of many traveling waves.

- From BOD analysis 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.
- We could simulate the numerical results with the amplitude equation for Complex Ginzburg-Landau- equation (CGLE).
- The theoretical simulation results give a good agreement with the numerical results for both space-time data and time series data.

Finally, The amplitude equation is a good method for theoretical analysis of weak non-linear glow discharge system that deals with glow discharge as fluid system and also as a wave-wave interaction.