CHAPTER 9

GENERAL CONCLUSIONS

The properties and behavior of gas discharges have been the subject of numerous investigations due to their growing interest in both fundamental and technological applications. It is widely used in gas lasers, radiation sources for generating light and for many spectrochemical applications. The characteristics of a gas discharge depend on various parameters like the electrode material, properties of gas, cell configuration, discharge condition and so on. Various techniques like emission or absorption spectroscopy, Langmuir probe, optogalvanic effect, etc. have been employed to characterize the discharge. Of these, the optogalvanic effect is unique and has several advantageous over other techniques. Here one essentially measures the change in discharge impedance as a result of absorption of radiation. Since the measurements are in terms of voltage change, all the spectroscopic and analytical studies can be made without any optical detection technique, so that the sensitivity is considerably high.

The spectroscopic investigations in gas discharges by laser induced optogalvanic effect and non-linear properties in the dynamics of the discharge plasma such as instability and various possible routes to chaos have been described in the present thesis. The discussion and results obtained from the present
investigations were included in the previous chapters. This chapter gives the general conclusions derived from the present studies.

The work presented in the chapters can be broadly divided as follows.

(I) Optogalvanic study in nitrogen and neon discharges

(II) Photoemission optogalvanic studies in Ne-Nd hollow cathode under cw laser excitation and two photon POG effect under pulsed laser excitation.

(III) Experimental study of non-linear properties in the dynamics of the hollow cathode discharge.

The optogalvanic studies were carried out in two ways; a) by resonant absorption of radiation usually known as optogalvanic effect and b) non-resonant absorption of radiation by the electrode material known as photoemission optogalvanic effect. In the first case, the wavelength of the radiation is required to be resonant to a transition related to any of the discharge species for generating the signal, whereas in the later case, it is generated by injecting photoelectrons into the discharge via photoelectron emission from the cathode. Even though the experimental procedure for these studies are simple and convenient, the presence of discharge noise as a result of random variations in current and gas pressure is a serious problem that limit the sensitivity of detection. However, this can be
minimized considerably by choosing a suitable cell configuration
and operating the discharge in a stable region of the discharge
using a highly regulated power supply and by maintaining a
constant gas pressure in the cell.

Home made cells with positive column and glow discharges as
well as commercial hollow cathodes and indicator glow lamps were
used in the present studies. Continuous gas flow cells with
de-mountable electrodes are found to be suitable for the
spectroscopic study of molecular gases.

The first positive system \( B^3\Pi_{\frac{e}{g}} \rightarrow A^3\Sigma_{u}^+ \) of nitrogen molecule
has been studied by using Doppler limited high resolution OGS.
Due to a good sensitivity of the method, OG resonances for a
large number of rotational lines belonging to \((10,6), (11,7)\) and
\((12,8)\) bands of this system have been observed. The studies show
that the method can be extend to investigate other band system by
varying the discharge conditions such as gas pressure or current
and a far better line accuracy and resolution can be obtained by
adopting Doppler free methods.

Simultaneous investigations of OG effect carried out for \( 1s_5 \rightarrow 2p_2 \) and \( 1s_5 \rightarrow 2p_4 \) transition in neon and the fluorescence
properties under resonant absorption of laser gives some very
interesting results. These are very useful techniques to
investigate the population distribution and hence the
modifications in the electrical and emission properties of the
discharge. Monitoring of these effects can also be used to
elucidate the mechanism of the optogalvanic effect.

As an alternative to conventional spectroscopic methods, the spectral profile of transitions belonging to highly excited state can be easily investigated by OG spectroscopy. The line spectral profile measurement has been carried out using OG effect and the line broadening coefficient, collision cross section, temperature etc have been evaluated for certain transitions in neon discharge. The spatial dependence of the OG signal has been found to give very interesting information on population distribution of species in the discharge.

The interaction of radiation with discharge medium by non-resonant process can be investigated by photoemission optogalvanic effect. This is useful for the study of photoelectric properties of the cathode material in presence of discharge as well as the physical processes involved in the interaction of photoelectrons with the plasma. The non-linear properties of the gas discharges such as multi photon absorption, discharge instability etc. have been studied here in detail by monitoring POG effect.

The order and chaos in dissipative system has been the subject of intense research due to their numerous potential applications. The gas discharge is a typical non-linear dynamical system with a large number of degrees of freedom. The non-linear behavior in gas discharges enables one to understand the chaotic behavior in the dynamics of a plasma discharge and
their sensitive dependence on the initial conditions. Here the existence of these non-linear properties that lead to various routes to chaos such as period doubling, Hopf bifurcation etc. are investigated by monitoring the discharge current as the control parameter.

In summary the various properties of gas discharges investigated by laser induced OG effect, POG effect and the current oscillations have revealed some of the interesting spectroscopic features and yielded information useful on non-linear behaviour in the dynamics of the gas discharges.