CHAPTER I

INTRODUCTION AND FORMULATION OF THE PROBLEM
The first nitrogen laser was built in 1963. It was a high voltage, pulsed discharge through flowing nitrogen gas in a capillary with mirrors at both ends of the discharge forming a cavity. A few of the bands belonging to \((B \, ^3\Pi_g - A \, ^3\Sigma_u^+)\) transition of \(N_2\) were found to lase. Later \((0,0)\) band of \((C \, ^3\Pi_u - B \, ^3\Pi_g)\) at 337.1 nm was found to lase so strongly that no mirrors were required and this radiation has been called superradiance. In normal parlance \(N_2\) laser means lasing at 337.1 nm with only one reflecting mirror at the back or no mirror. Since these early years the emphasis has been to build different models of \(N_2\) lasers with a view to achieve one or more of the following: high power, high repetition rate, long/short pulse widths. Studies of pulse shape and output, and their relation to power input, channel dimensions, pressure and flow patterns have been reported. Simple theories based on direct electron excitation of \(C\) and \(B\) states have been developed and applied to gain an understanding of the mechanism of these lasers.

\(N_2\) laser radiation has been spectrally examined and gain curves have been determined at different pressures and temperatures. A simple model that is qualitatively satisfactory has been used to interpret these gain curves. There are two reports about the relation between spontaneous and laser radiation in \(N_2\) lasers but they are
not extensive enough to include emission from levels other than \( v' = 0 \). Also the correlation between spontaneous and laser radiation has not been examined critically, though there are a few reports for relativistic electron beam experiments.\(^\text{136,144,146}\)

\( \text{N}_2 \) is an important molecule possessing a large number of electronic transitions and these have been subjected to many spectroscopic investigations: wavelength determinations, measurement of molecular parameters through high resolution studies, intensity measurements, lifetime studies, theoretical calculations of Franck-Condon factors. Some of these data are used to understand laser mechanisms and gain curves. An important data required in this respect are the intensities of bands and lines. We do find from literature\(^\text{167-169,171,173}\) an abundance of data on intensity measurement of \( \text{N}_2 \) \((\text{C} \rightarrow \text{B})\) bands but they do not appear to agree well with one another indicating the dependance of intensity distribution on experimental conditions. In addition, a consistent set of intensity measurements are necessary to have an unambiguous determination of electronic transition moment variation for the \( \text{N}_2 \) \((\text{C} \rightarrow \text{B})\) transition. In this connection we are not aware of any intensity measurements from the laser discharge for the entire band system which would provide a set of data that would help in understanding the changes in populations of \( v' = 0, 1, 2, 3 \) levels of the C-state as function
of pressure and flow as the discharge is taken from the
stage of non-lasing to that of best lasing and beyond in
steps. This is expected to provide a comparison of the
populations of \( v' = 1, 2, 3 \) amongst themselves and their
comparison with that of the \( v' = 0 \) level. These populations
are significant in the lasing process. This is expected
to provide correlation between the spontaneous emission from
level \( v' = 1-3 \) and the lasing emission from level \( v' = 0 \).
In order to understand the relation of spontaneous emission
to laser emission which is directional along the length of
the discharge, it was also thought necessary to determine
these intensities in a direction perpendicular to the
discharge. The totality of the data is hoped to add to the
body of knowledge on \( N_2 \) lasers and lead to a greater under­
standing of the relation between spontaneous and laser
emission in this molecular source.

In order to do this we thought it advantageous to
build a \( N_2 \) laser ourselves and in the process develop the
skill for building one with adequate power to pump dye lasers.
It was considered desirable to build an inexpensive laser
so that the know-how could be transferred to teaching and
other laboratories that are bogged down for lack of funds.
Such a laser has to be provided with facility for measure­
ment of intensities in two directions, one along the
discharge and another perpendicular to the discharge. Since
the laser was being built anew it was thought worthwhile to build a few models so that we gain first hand experience about the role of design parameters, surface of the laser channel, addition of gases and reflectivity of the rear mirror on the power output characteristics. The experience and the data are expected to bridge some minor gaps and provide us the skill to operate them efficiently. This in turn is hoped to improve our understanding of lasers.

With this end in view we have reviewed the literature on $N_2$ lasers in the next Chapter and presented the details of fabrication of $N_2$ laser and measurements in subsequent Chapters.