Chapter 1
Introduction

Unlike most objects studied in astrophysics, the Sun has a considerable influence on our daily lives. To the casual observer, it may appear that the only thing the Sun does is to provide us with an almost constant and totally predictable source of energy, and that any changes occurring on the Sun are of only purely academic interest. Fortunately for those studying the Sun, this is far from the case.

One of the most obvious solar changes to affect us is the variation in the number of sunspots and other types of solar activity. This activity affects such things as radio communications and the health of satellites. It even appears that a major power outage in Canada was due to the effects of solar activity. It has also been speculated that long-term variations in the Earth's climate may be due to variations in the solar energy output.

Solar activity is believed to be closely related to the solar rotation and magnetic fields. It is generally believed that the solar activity cycle is caused by an interaction between the differential rotation, the magnetic fields, and the convection in the solar envelope.

The solar rotation and general structure is also important for other parts of physics, such as general relativity and particle physics. If the Sun had a rapidly rotating interior, the test of general relativity using the advance of the perihelion of Mercury would have a serious problem. Particle physics and solar physics are connected by the so-called solar neutrino problem, which manifests itself in the fact that the number of solar neutrinos observed is considerably less than that predicted by standard solar models and particle physics.

The relatively new area of solar physics called helioseismology, the subject of this thesis, has proved to be an invaluable tool for investigating these and other properties of the solar interior.

In helioseismology, the solar interior is studied by observing the normal oscillation modes of the Sun. Using the observed frequencies, it has proved possible to infer the solar rotation rate over a substantial fraction of the solar interior. It has also been possible to infer other properties of the solar interior such as the dependency of the sound speed on radius and properties of the convection.

Unfortunately, it appears that the measurements of the oscillation frequencies are susceptible to a number of systematic errors which, given the nature of the methods used for inferring the solar internal rotation rate, can lead to serious problems.

The subject of this thesis is a study of a method to measure the oscillation frequencies and various methods to infer the solar rotation rate from these measurements.

In the coming years a number of new and considerably improved instruments will become operational. In particular, the so-called GONG experiment in which 6 identical instruments will be placed around the Earth to be able to observe the Sun continuously and the SOI/MDI experiment on the SOHO satellite are expected to give us observations of a vastly improved quality and quantity. It is the hope that some of the methods described in this thesis will be of use for these and other projects.

1.1 Overview

In the following I will start with a short description of some of the basic properties of solar oscillations. As these properties have been covered in many excellent reviews and papers, I will not go into any details or derive any equations.

In the next chapter, I will describe the Fourier Tachometer and parts of the analysis of the data obtained with it. I will discuss many of the details of the analysis not covered elsewhere and some of the properties of those runs of the Fourier Tachometer that I have been involved in the reduction of. I will also discuss some of the results we have obtained and some of the tests performed to look for systematic errors in the analysis. This chapter is the only part of the thesis that has been written as a fairly integrated chapter. Major parts of the analysis process and some of the results obtained are, however, covered in some of the papers included in the appendices.

The next chapter contains a short introduction to helioseismic inversions. The main part of my work on the inversions has again been covered in the papers included in the appendices.

The last chapter contains a short conclusion linking the results obtained in the two previous chapters.

In a sense the appendices form the main part of the thesis, as they contain the papers written by me and by others together with me on the subjects covered in the rest of the thesis.

This version of the thesis has been edited slightly compared to the original version. Most of these changes were made to correct punctuation, typographical errors and incorrect sentence structures.