Chapter 1

Introduction

There are many stars that display irregular variations in their light output. These stars are classified as irregular variables. Stellar photometry, where the varying output is measured using several wavelength bands, is the most common method used to study these stars, however should an “outburst" or sudden significant increase in light output occur, then spectroscopy is desirable. Unfortunately, in most cases, access to a suitable telescope and spectrograph at only a moments notice is rarely possible.

In recent years both professional and amateur astronomers in the U.S.A. have set up automated observatories, with telescopes ranging in aperture from 0.2 to 1 metre. Operating under computer control these observatories can take photometric measurements on a large number of stellar objects in a single night. There is little or no human intervention, other than to inform the controlling computer of the objects to be observed. A number of these telescopes / observatories are describes by Hall et al. [1986].

The next step in the evolution of this type of observatory, as suggested by Nations and Seeds [1986], will most likely be to include more advanced instrumentation, such as spectrographs. It is for such an application that the University of Queensland Echelle Spectrograph **(UQES)** is being developed.

1.1 Design Philosophy

When considering the design for the spectrograph, it's intended application was a major factor. Considering the relatively small telescope sizes, for the spectrograph to be mounted on the telescope it would have to be both small and of low mass. Even the larger 0.8 metre telescopes, such as those sold commercially by AutoScope™, have little space for additional instrument packages. This can be solved by mounting the spectrograph away from the telescope and using an optical fibre to transfer the light. Although no longer mandatory, a compact design is still desirable to allow installation in smaller observatories. Transportability, and the possibility of an environmentally controlled enclosure being used, are factors that were also considered.

For the spectrograph to be of practical use as part of an automated patrol system then both complete visible spectral coverage and short measurement times are required. Even a moderate resolving power of $\sim$20000 (compared with 38000 for a similar design by Baudrand and Böhm [1992]) is in conflict with this requirement if a standard design of grating spectrograph is used which is capable of acquiring only small sections of spectrum at a time. This is because of the need for a large number of exposures and hence long measurement times. The solution is to use an echelle spectrograph design.

The general theory of the echelle (French for ladder, scale or pair of steps) and techniques for it's production were first discussed Harrison [1949], but it was not until the late 60's that the successful production of high quality replica echelle gratings aroused the interest of astronomers. Much of this interest is due to some important properties of the echelle [Schroeder, 1970]:

- An echelle grating has a much higher angular dispersion than a low blaze grating, allowing the use of shorter camera and collimator lenses;

- The optical through-put of an echelle spectrograph is larger than a normal grating instrument at the same resolution;

- Large wavelength coverage in a convenient 2-D format for electronic detectors such as the computer controlled CCD detector proposed for use with this instrument.

One last consideration is cost. In order to reduce the overall cost of the instrument, commercially available optics are used wherever possible. In the current prototype version both the collimator and camera lenses are standard 35mm SLR camera objectives.

1.2 Scope of Investigation

The objective of this study is to design and implement a prototype fibre fed echelle spectrograph. In the next chapter details are given of the design of the spectrograph including component choices. Based on this, the format of the resulting spectra is illustrated. Following chapters contain analyses of the components which are then combined to provide theoretical images, resolution and through-put for the completed instrument. The performance is then measured and compared to the expected results to determine the areas where the design may be improved.

A detailed description of simulation software (AAT echelle), shown in Figure 1.1, is presented in an appendix, with a modified version being used to generate some of the illustrations in this paper.

Figure 1.2 is an early mock-up of the prototype spectrograph used for determining component spacing and orientation. The version of the prototype used for testing is essentially the same with the exceptions of the detector (foreground) and the fibre coupling to the rear of the collimator (background).

Figure 1.1: ECHWIND-PC simulation software.

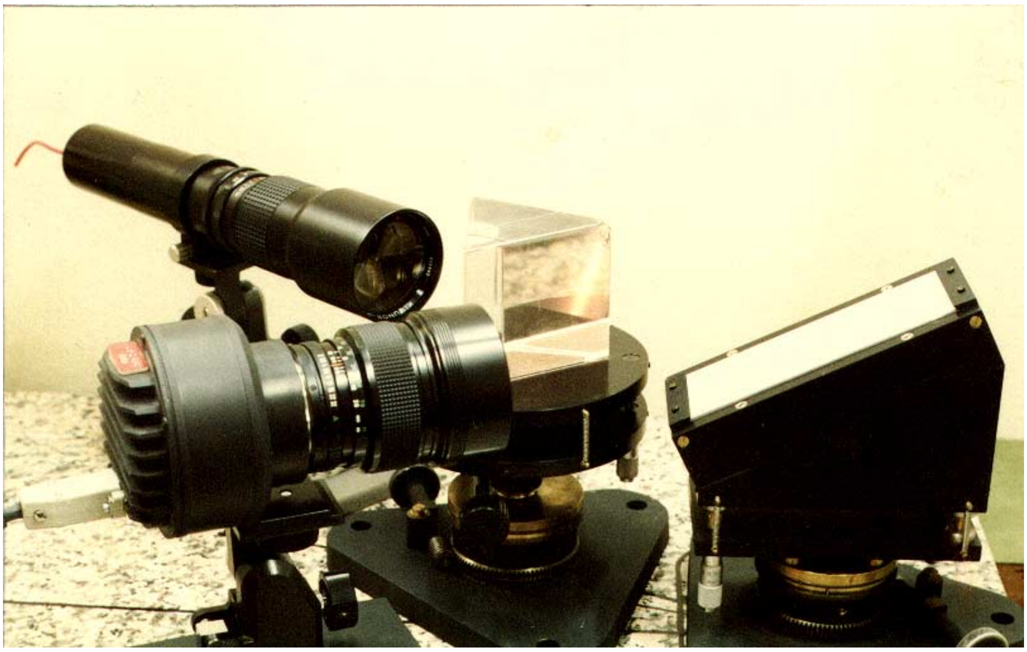

Figure 1.2: Mock-up of prototype spectrograph.