Red Supergiant Stars within the Local Group

Lee. R. Patrick

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The University of Edinburgh
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Chapter 1

Spectroscopy with the K-band Multi-Object Spectrograph

1.1 Introduction to Spectroscopic Techniques

Spectroscopy is the study of the dispersion of light into its constituents and has been at the forefront of astronomy for roughly the last 200 years. Sir Isaac Newton demonstrated the principles of spectroscopy (and coined the term "spectrum") using light from The Sun in his seminal "Opticks" work (**?**). By using the groove spacings on a diffraction grating, Thomas Young first quantified the wavelengths of different colours of light (**?**). The simple set-up of a spectrograph, which has - more or less - been used since the early spectroscopic experiements, consists of five basic elements:

i Slit

ii Collimator

iii Dispersive element

iv Camera

v Detector

In Newton's demonstration he used a small hole in his window blinds as a slit and a screem as a detector. The slit in modern spectroscopic observations can

Figure 1.1 *Three panels demonstrating long-slit spectrscopy*

take various forms. The most widely used type of slit, in modern observations, is long-slit spectroscopy. Using a long slit, a spectrum is taken for each spatial pixel along the length of the slit. This is demonstrated in Figure 1.2, where the final panel shows that each pixel illuminated by the slit produces a spectrum. This can be thought of a 2-dimensional spectroscopy, which is particualrly useful when attempting to take a spectrum of an extended object (rather than a point source).

As an alternative to using a long-slit to remove contamination from other sources, is to use a small hole or fibre to select the target flux. By precisely drilling a hole in a metal plate, a slit is created which can be used to select the target flux. One of the advantages of using this method is that more than one object can be selected for a single exposure. By creating multiple slits within a single plate, spectroscopy from multiple objects can be obtained where contamination from other sources is minimised. An improvement to this method was to use optical-fibres positioned within the holes. The fibres could then be led to an instrument which was not directly attached to the telescope, which has the advantage that the instrument will not suffer from the changing gravitational force as the telescope moves. In addition, the conditions within the instrument room can be controled. This is particularly important for near-IR spectrographs and detectors.

However, using a plate with several holes drilled into it has some drawbacks. These include the time in which it takes to create the slit mask, the lack of flexibility while observing and the operational costs of creating a new mask each time a different field is to be observed (Parry & Gray, 1986). These reasons, in addition to improved computing power, led to the development of instruments which were able to automatically position fibres (Tubbs, Goss & Cohen, 1982). Most modern fibre-fed spectrographs have automatic fibre positioning technology which is broadly split up into two approaches.

i Each fibre has a magnetic button attached and a single robot is charged with moving each fibre sequentially. This is an effective method to place large numbers of fibres, but does however, take a significant length of time for each configuration.

ii Each fibre is mounted upon a computer controlled arm. This method is

Figure 1.2 *Three panels demonstrating long-slit spectrscopy*

generally less time consuming.

As a variant on the five basic elements of a spectrograph, slitless spectroscopy is also a feasible option which is not discussed in detail here. For more information on slitless spectroscopy see Fergus' thesis!

Dispersive elements ...

- Compare prims and diffraction gratings ()
- Describe diffraction gratings in detail and how they are made
- Why do different gratings select different wavelengths?

Camera ...

- Brief mention, if at all.
- Focuses the light again

Detector ...

- Brief comments on specialisations for near-IR
- i.e. Cooled etc.

Young, T., Phil. Trans. R. Soc. 92, 12 (1802)

1.2 Integral field spectroscopy

How exactly does IFU spectrosocpy work again . . . ?

- Image slicer!

1.3 Instrument

1.4 Data

1.5 Data Reduction

1.6 Conclusions

Bibliography

Parry I. R., Gray P. M., 1986, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 627, Instrumentation in astronomy VI, Crawford D. L., ed., pp. 118–124

Tubbs E. F., Goss W. C., Cohen J. G., 1982, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 331, Instrumentation in Astronomy IV, p. 289