THESIS ABSTRACT

The Development of New Techniques for Integral Field Spectroscopy in Astronomy

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Integral field spectroscopy (IFS) is the ability to record spectral information from all pixels on an astronomical field. Regions of interest include the cores of galaxies and images produced by gravitational lenses, where the velocities derived from the spectral lines across the whole field of view can map the dynamic conditions of gas and nebulae in these objects. Classical long-slit spectroscopy can only record a single line of information per exposure, and if more data are needed then the slit has to be rotated or moved and another exposure taken. For faint objects that require long integrations only three or four such exposures can be taken in one night, leading to inefficient and incomplete sampling.

IFS requires new instrumentation techniques to reformat an area of sky into a long slit suitable for dispersion with a spectrograph, and new computer software to reconstruct the image of the sky for a given spectral line or region.

This thesis begins with a review of different IFS techniques, suggesting that the use of optical fibres as spatial reformatters leads to one of the simplest optical designs. Investigating the transmission properties of optical fibre leads to an efficient spectrograph design optimised for use with a dedicated fibre-feed, and such a prototype spectrograph (called *SPIRAL - Segmented Pupil/Image Reformatting Array Lenslets*) was built and tested at the *Anglo-Australian Telescope*.

The techniques for accurately handling and positioning fibres in this prototype are presented. Subsequent developments of these techniques are then successfully used in the construction of an IFS unit and twin optical fibre feed for the *Cambridge OH Supression Instrument (COHSI)* infra-red spectrograph.

Information from IFS is in the form of a 'data cube', with flux as a function of x, y, and wavelength and this three-dimensional array of data can be interpreted in many ways. The computer data reduction techniques are closely linked with the software needed for presentation and interpretation of the data, and *IRAF* programs developed for this purpose are presented along with scientific results from the *SPIRAL* spectrograph. A discussion and some simulations of cross-talk effects induced in closely packed spectra are also presented.

The supernova SN1987A and the discovery of a brown dwarf with the *SPIRAL* spectrograph demonstrates the efficiency and capability of IFS for small fields of view. This leads to the design study of a larger fibre image reformatter *SPIRAL 'B'*, in which the techniques and methods developed with *SPIRAL* and *COHSI* are incorporated.

Many of the next generation of telescopes have plans for instruments with IFS capabilities and this thesis goes toward addressing some of the issues involved with these new and powerful instruments.— *University of Cambridge; accepted 1998 December*