TAURUS - A Wide Field Imaging Fabry-Perot Spectrometer

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TAURUS, an imaging Fabry-Perot system, was developed as a collaborative project by the Royal Greenwich Observatory and Imperial College London and is capable of obtaining seeing-limited velocity field information over a 9 arcminute field on a 4 m telescope. At the detector (the IPCS) the image of the source is modified by the fringe pattern of the capacitatively stabilized servo-controlled Fabry-Perot. As the Fabry-Perot is scanned, this fringe pattern tracks radially across the field and each pixel of the detector maps out a spectral line profile within the bandpass of the "blocking" interference filter. At each F-P spacing a picture (Typically 256 x 256 pixels) is recorded on computer disk. 100 pictures make up a complete scan, covering for example 1,200 km sec^{-1} free spectral range (this range in practice depends on the particular etalon). In this manner a 3 D data cube of the field is built up where (X, Y, Z) are typically (256 pixels, 256 pixels, 100 steps).

If we plot the intensities recorded by 1 pixel through the scan range, we see the spectral line profile for that part of the object being observed. Because the light from different parts of the field passes through the etalon at different angles, there is a shift in the wavelength zero-point as a function of field angle. Because of this the (X, Y) pictures of raw data are not monochromatic. This positional dependence of wavelength is calibrated and then corrected for by shifting each profile in the computer so as to line up the zero point at all (X, Y) positions - a process known as phase correction. The phase corrected data cube has X, Y as spatial dimensions and Z as a wavelength dimension. These data are then analysed by viewing X, λ or Y, λ plots or as a "movie" of a rapid sequence of (X, Y) pictures as a function of λ, enabling us to view different parts of the objects at different velocities. By summing all the pictures in λ we may produce the equivalent narrow band interference filter pictures, as if the Fabry-Perot were not in the system. By summing in X or Y we may produce an X, λ or Y, λ plot

E. Athanassoula (ed.), Internal Kinematics and Dynamics of Galaxies, 31–32.

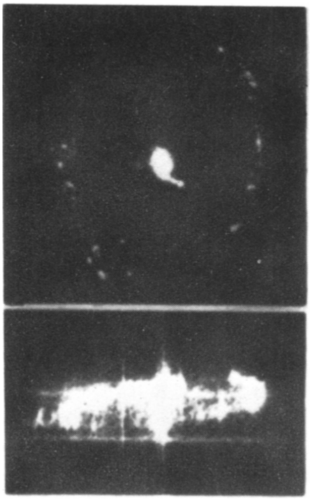

Fig. 1 (upper) is an image of the barred spiral galaxy NGC 1365 in Hα, resulting from summing the data cube in the z or λ direction. Fig. 1 (lower) is a position velocity plot obtained by summing all the phase corrected data in the Y direction and shows velocity as a function of the X coordinate (in this size R.A.) over the whole galaxy. The vertical straight lines represent the continua from stars in the field whilst horizontal streaks are night sky features. The ellipsoidal structure traces the regular large scale motion of the HII regions in this galaxy.

similar to the display of 2D long slit spectra. In these, night sky lines should appear straight across the field, indicating the accuracy of the phase-correction process.

The data may be analyzed to produce velocity maps and line width maps at the seeing-limit using techniques similar to those employed when reducing channel maps obtained through HI radio synthesis observations.

This technique is superior to grating spectrographs for obtaining velocity field information from extended emission line sources (such as galaxies, supernova remnants, planetary nebulae, HII regions etc.) because the information is concentrated in only a small part of the spectrum but over a wide field. Whilst a grating spectrograph looks at all the spectral elements all the time across the field defined by a narrow slit most of these elements contain no information concerning the velocity field. In TAURUS we have traded the spectral multiplicity for a spatial multiplicity and obtain spectral elements sequentially over a small wavelength region centred on the emission line of interest. This method is typically 10 to 20 times faster than grating spectroscopy when studying large objects (> 1' diameter).

References

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Atherton P.D., Taylor K., Pike C.D., Harmer C., Parker N.M., Hook R.N., MNRAS, 200, 1982.