soon APM scans of Schmidt plates where available). Internal accuracies are better than 0.1 arcsec with external errors to ~0.25 arcsec.

The catalogue generator produces seeing estimates, sky brightness/arcsec^2, limiting magnitudes, etc. These are stored in the FITS headers. Flux calibration will typically be good to 0.05 mag.

Survey Progress: Data Products

The data products available for access include:

- Observing logs built from the FITS headers.
- A 'sybase' user interface to access. the raw and processed data.
- Library bias frames, flat-field frames, defringing frames and non-linearity corrections.
- Colour equations for all filters.
- Processed 2D image maps, with a full record of processing steps in the FITS headers.
- Astrometric calibration, with the World Coordinate System in the FITS headers.
- Photometric calibration – zero points and extinction.
- Data quality control plots.

In the coming months the data products provided will be expanded to include:

- Object catalogues, generated using APM based routines (Irwin, 1985) and possibly SExtractor (Bertin and Arnouts, 1996) to give positions, magnitudes, image quality, etc. These will be stored as FITS binary tables with original 2-D image frame headers.
- Multicolour object catalogues, with cross-referencing of colour data to provide sub-sample selections based on colour-colour diagrams.
- An improved user interface to the WFS archive via the WWW front end, giving, for instance, the ability to extract arbitrary regions etc.
- Improved cross referencing to other survey data (e.g. FIRST, 2dF, AXAF) available for WFS fields.
- Association with reddening maps and HI maps. ¤

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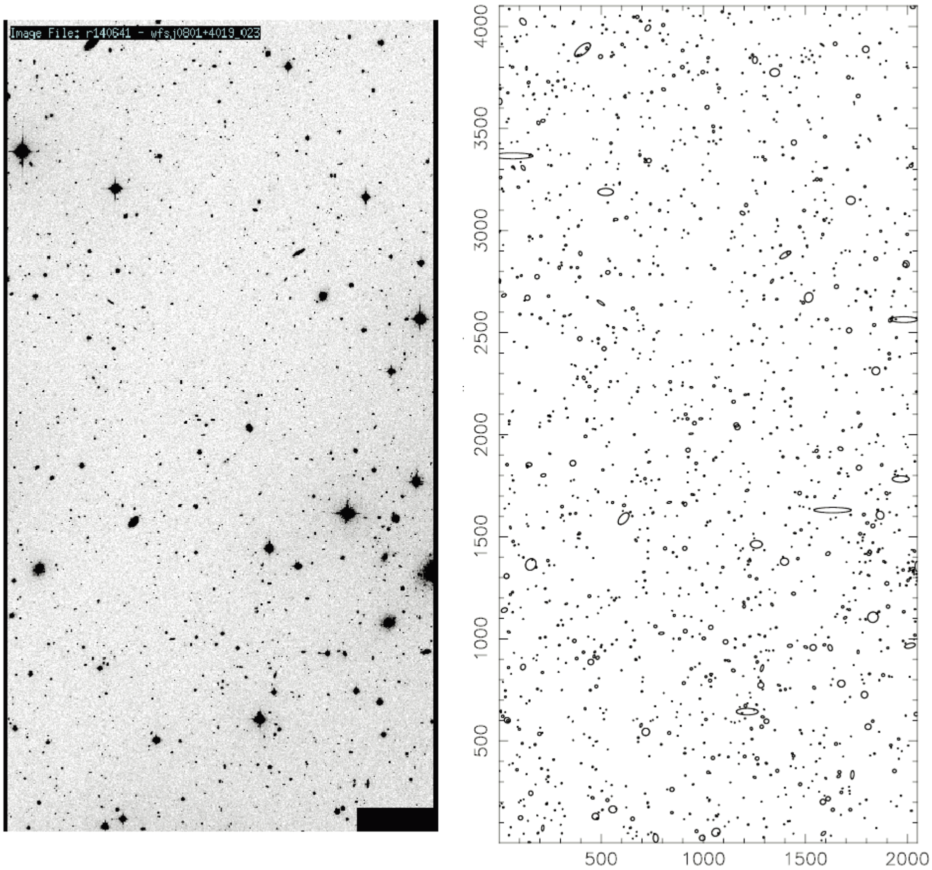

Figure 1. A processed 600 s R band image (1.0 arcsec image quality, ~11 x 22 arcmins, this being one of the four images obtained in each exposure) is shown in the left panel, with the APM object catalogue representation on the right (~1600 objects are identified in this at the 5 sigma detection level).

Extragalactic Stellar Spectroscopy

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The advent of large 8–10 m telescopes heralds a new age in stellar astronomy. It is now possible to carry out detailed spectroscopic observations at high resolution of the brightest stars of galaxies in the Local Group, and it is envisaged that intermediate resolution observations will be extended to stars in the nearest galaxy clusters such as Virgo and Fornax. For some years the authors have been carrying out the groundwork involved in identifying young massive supergiant stars in nearby resolved galaxies, with a view to performing follow-up detailed studies of selected samples. In this article we summarize the contribution that the William Herschel Telescope has made to this project, and further, show that even a 4.2 m telescope with a blue sensitive, large format CCD at a good site with dependable sub-arcsecond seeing can make an important contribution to the detailed study of our nearest spiral neighbours M31 and M33.

We have two primary objectives in the study of massive stars in nearby galaxies; one is to use these objects as probes of the present day chemical composition and the second, which will not be discussed in detail here, is their use as standard candles. Blue supergiant stars have absolute visual magnitudes in the range –7 to –10, and may be conveniently split into B-type and A-type stars. The B-type objects typically have broader lines (with widths corresponding to Doppler velocities of 50–100 km/s) and have many strong isolated lines of light elements such as C, N, O, Si, and Mg. A-type supergiants on the other hand have somewhat narrower line-widths and many weak lines of Fe-group, s- and r-process elements. Hence a detailed analysis of a sample of these objects can provide very powerful constraints on models of a galaxy's evolution. However as AB-type supergiants are relatively young stars, we are restricted to galaxies with active star formation, typically spirals and dwarf irregular galaxies. In the rest of this article we will concentrate on some work which has been performed on M31, the largest and most luminous galaxy in the Local Group.

The brightest stars in M31 were originally studied spectroscopically by Humphreys (1979), from a sample selected from photographic photometry. The selection was performed on the basis of magnitude and colour, and we have essentially repeated this selection using the CCD photometric catalogue of Magnier (Magnier et al., 1992 and Haiman et al., 1994). Our colour magnitude diagrams covered $16.0 < V < 18.5$, and colour range $B-V < 0.4$, within which single O, B, A and F-type supergiants members of M31 should lie. These criteria resulted in a sample of several hundred blue supergiant candidates. At the distance of M31, 1 arcsec corresponds to 3.4 pc and hence some of our chosen objects turn out to be composites, with spectral signatures of two (or more) stars of differing spectral types. Additionally the highly variable reddening across M31 requires that the red cut-off is relatively high, which then encroaches on the colour-magnitude region occupied by Galactic foreground late types and subdwarfs. Hence low-resolution spectroscopy is an essential filter for target identification.

The combination of AutoFib2 and WYFFOS on the WHT is ideal for this kind of project – approximately 90 science fibres can be placed within the 1 degree un-vignetted field of view at Prime. We match the Magnier CCD colours of our selected objects to the astrometric coordinates from APM plate scans to provide the necessary accuracy (0.2 arcsec) for AF2 fibre placement and consistency with fiducial guide star positions. We have already had a successful observing run in December 1997 when we obtained spectra of approximately 100 supergiants in M31, with another

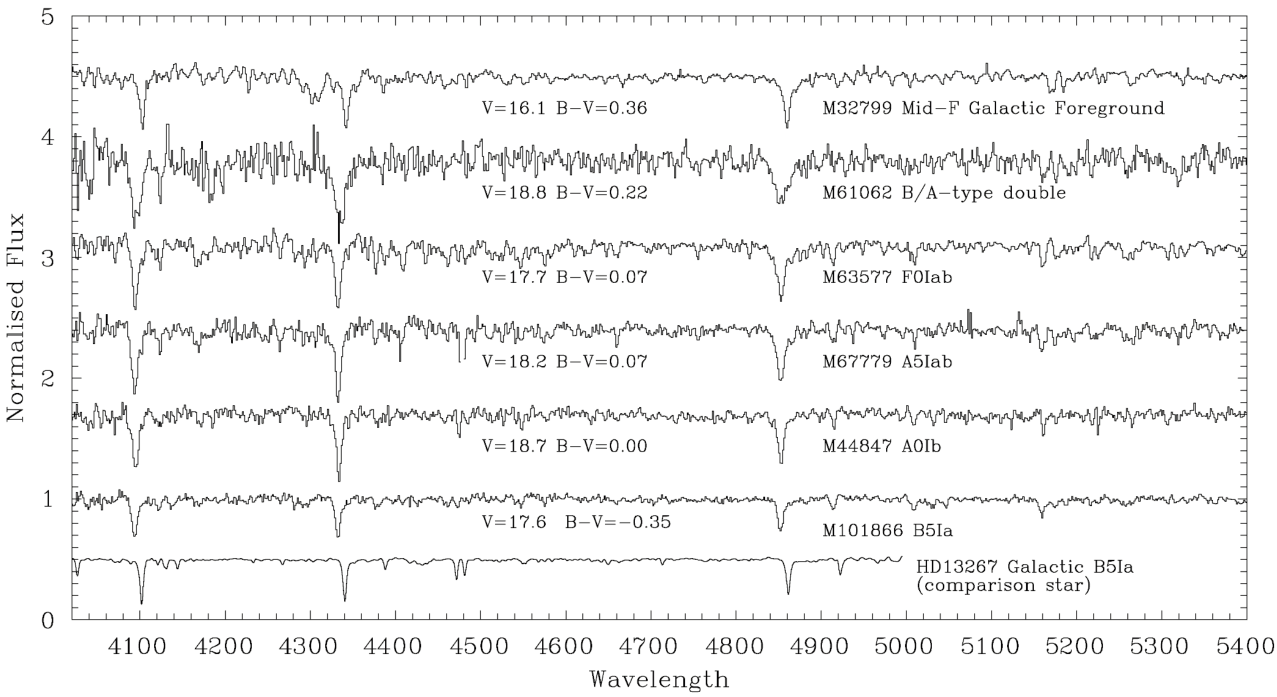

Figure 1. Four massive supergiants spanning the spectral range mid-B to mid-F are shown from the AF2/WYFFOS run in December 1997. Their spectra are velocity shifted by approximately –550 km/s, consistent with membership in the SW spiral arms of the galaxy, and the visible lines are consistent with them being single evolved massive stars with the given spectral types. We show a nearby Galactic spectral standard (HD13267), convolved to the same resolution as the WYFFOS spectra. Visible in the B-type spectrum are lines of He I, Si II and Mg II, and as He I disappears in the later types Si II 4128–30 and Mg II become stronger and Fe II (e.g. 4173–8) starts to appear. The Fe II lines are clearly visible in the F0Ib spectrum along with additional lines of Sr II and Ti II. Also shown are examples of a composite spectra, M61062 (the hydrogen lines are clearly split, and of approximately twice the strength of late-B early A-types) and a late-type Galactic foreground star, M32799).

run scheduled in autumn 1999. With a spectral resolution of 2.5Å, we are able to reliably classify large numbers of targets, and typical results from these observations are shown in Figure 1.

Follow-up ground-based high resolution spectroscopy is also planned and in fact this has already begun with some successful runs on the Keck I with the HIRES spectrograph (McCarthy et al. 1997, Venn et al. 1998). For M31 however, a lot can be achieved for B-type supergiants with intermediate resolution spectroscopy, concentrating on the strong lines in the earlier spectral types. Last year, we were fortunate enough to have a WHT/ISIS observing run with sub-arcsecond seeing (0.4 arcsec at one point), during which we obtained medium resolution (1Å FWHM spectral resolution) spectra of 18th magnitude supergiants. Early B-type supergiants have a strong tendency to show relatively broad metal line widths (e.g. virtually always having velocity broadening of greater than 60 km/s; Howarth et al., 1997) thus a spectral resolution of 1Å is sufficient to satisfactorily sample the line widths. One setting with the new EEV42-80 CCD on the blue arm of ISIS allows coverage from 3960 to 4720Å together with excellent efficiency. This provides all the blue atmospheric diagnostics required for model atmosphere analyses – allowing *detailed* abundance determinations in stars down to V ~ 18.5 on a 4 m telescope. The quality of the spectra are shown in Figure 2, and compared to the spectrum of a nearby, Galactic standard B-type supergiants. This demonstrates quite clearly that the metallicities of the M31 supergiants are close to solar, which is not entirely unexpected given that the galactocentric radius sampled by our objects is expected to have roughly solar metallicity from H II region results (Blair et al., 1982).

Blue supergiants can also be used as standard candles as their mass-loss rates provide an estimate of their luminosity. The most important diagnostic of mass-loss in this context is the profile of the Hα line, which for the most luminous supergiants is in

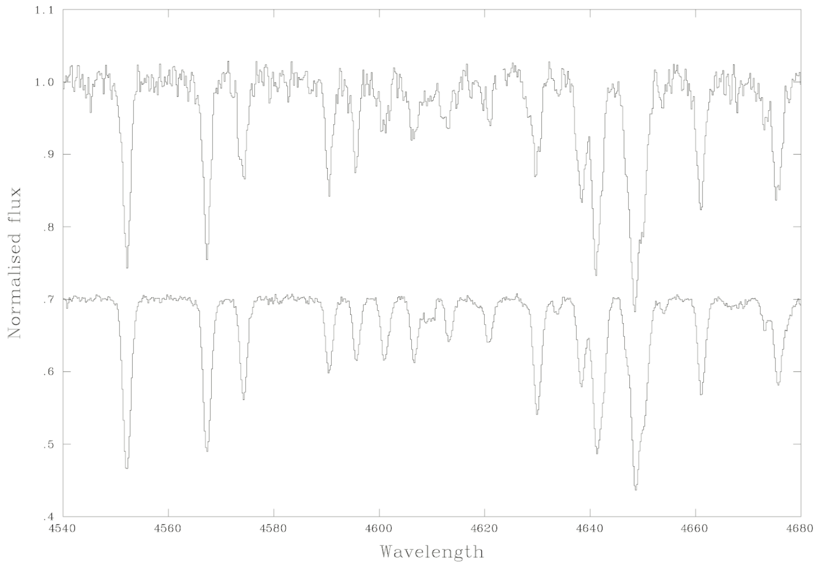

Figure 2. This figure compares spectra of the M31 and Galactic B1Ia supergiants OB78-159 (top) and HD194279 (bottom). The spectral range covered contains the Si III triplet at 4553/4567/4574 Å, and a number of O II and N II lines between 4590 and 4680 Å. The M31 spectrum is a 1 hour exposure obtained with ISIS on the WHT at a resolution of 5000 in half-arcsecond seeing, the star has a visual magnitude of 17.97. The difference in the line strength ratios of O II 4590/4596 Å and the N II lines at 4601/4607 for example, is due to a slight temperature difference, OB78-159 being the hotter star. The detailed model atmosphere analysis of OB78-159 is underway, however we can already see that the metal line spectrum is consistent with a composition similar to supergiants in the solar neighbourhood.

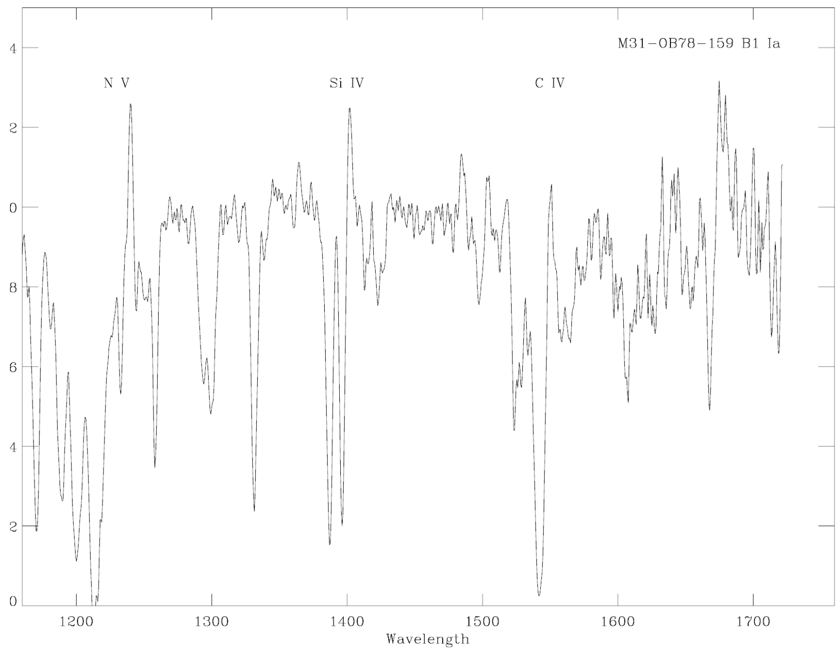

Figure 3. HST/STIS spectrum of OB78-159 obtained in 3 orbits using the G140L grating, long slit and FUV-MAMA detector and a total exposure time of approximately 8000 seconds. Strong P-Cygni wind lines of N V, Si IV and C IV are clearly visible and can be used to derive the terminal velocity of the stellar wind.

emission. Ideally one also requires observational constraints on the wind velocity law and terminal velocity which are best derived from ultra-violet spectra which contain strong wind lines. M31, together with the Magellanic Clouds, are important test beds for this approach. The most luminous stars are within the reach of the Hubble Space Telescope (HST) and its UV spectroscopic instruments and there is an ongoing HST spectroscopic campaign to obtain UV spectra of blue supergiants which have been well observed from the ground. The first such spectrum from the M31 campaign, obtained in January this year, is shown in Figure 3 for the B1Ia supergiant OB78-159 discussed above.

This project is continuing with the ING's wide field imaging and spectroscopic facilities, the Wide Field Camera and AF2/WYFFOS, which will lead to the detailed follow-up programs. We can already use ISIS on the WHT for detailed analysis of the brightest stars in interesting nearby galaxies such as the other Local Group spiral M33 and the dwarf irregulars like IC10, IC1613 and NGC6822. For the A-type supergiants (at higher resolution), and objects further afield we plan to extend this work using facilties on Gemini North (GMOS-N) and South (GMOS-S, HROS).

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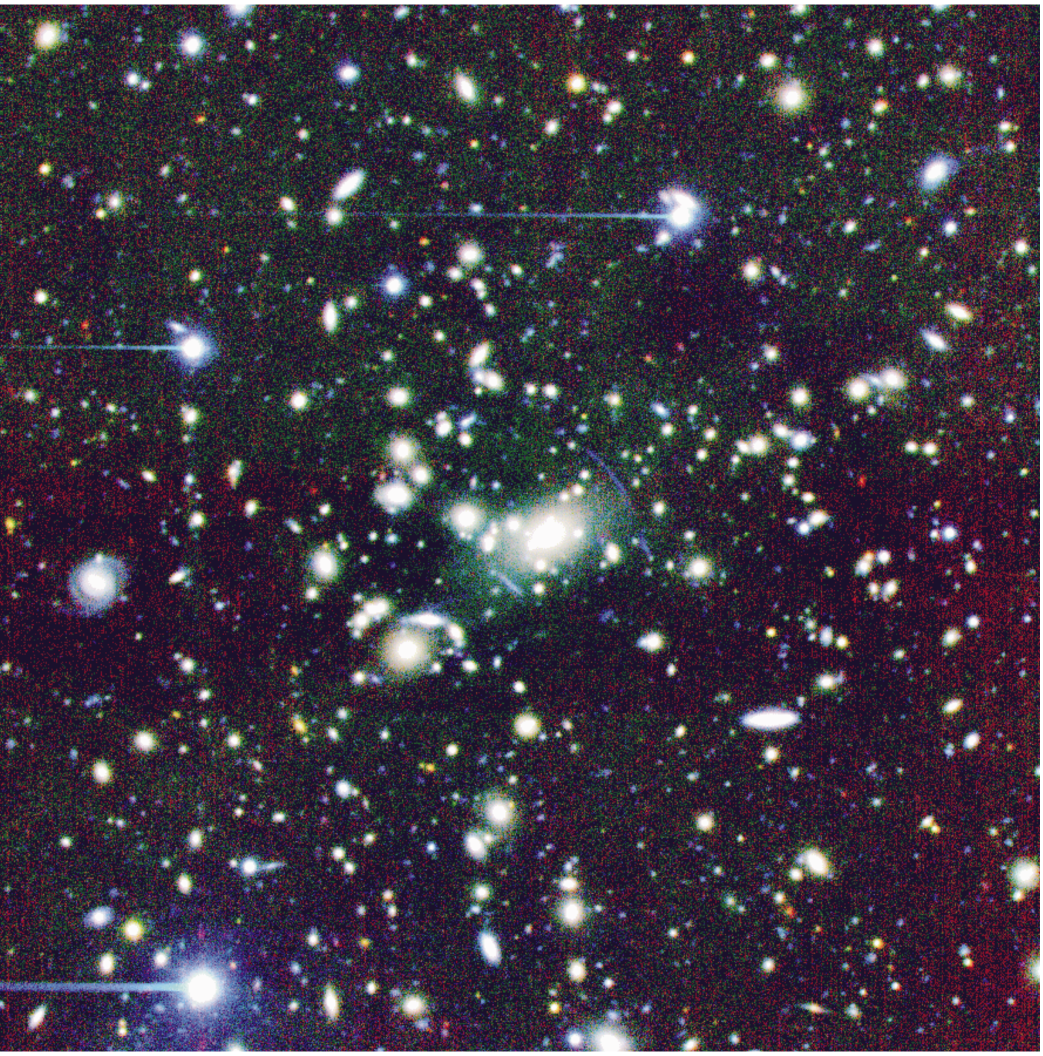
The Cluster of Galaxies Abell 2219 as seen by CIRSI



CIRSI is a panoramic wide field near infrared imaging camera which uses 4 Rockwell HgCdTe 1024 x 1024 detectors. The survey instrument is as scientifically versatile and as easy to use as a large format CCD camera and was first used on the INT in December 1997. It is particularly well-suited for surveys of star-forming regions, low mass stars, distant galaxies, clusters and QSOs. The CIRSI Project team consists of Dr Martin Beckett (Project Engineer), Dr Richard McMahon (Project Scientist), Dr Craig D Mackay (Project Manager), Mr Michael Hoenig (Graduate Student) with additional support from the rest of the Instrumentation Group at the IoA and many others.

The rich cluster of galaxies Abell 2219 (z=0.228) is a massive gravitational lens. This picture shows a 3 colour image of the galaxy cluster based on a 2.5 hour H band exposure obtained with CIRSI combined with B and I band optical CCD images. This image was obtained on the 4.2 m William Herschel Telescope in June 1998. It reveals evidence for lensed features. The observations are being used to trace the dark matter distribution within the cluster The field of view is 4.8 arcmin x 4.8 arcmin and the measured seeing in H band images is 0.7 arcseconds (this image is courtesy of Richard McMahon and Konrad Kuijken).