FMOS and UKIDSS Galactic Astronomy

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1 Introduction to UKIDSS and the UKIRT Wide Field Camera

UKIDSS (the UK Deep Infrared Sky Survey) is composed of 5 surveys with the new UKIRT Wide Field Camera which are to begin in summer 2004. These surveys will be publicly available to all members of ESO countries and to several Japanese astronomers who are participating. The surveys are described in detail at www.ukidss.org.

The UKIRT Wide Field Camera is being constructed at the UK Astronomy Technology Centre in Edinburgh (see www.roe.ac.uk/ukatc/projects/wfcam/). It is a 0.8 to 2.5 μm imager with 4 non-contiguous 2048^2 HAWAII 2 arrays. These produce a contiguous field of view of 0.76 deg^2 in 4 offset integrations.

The 5 UKIDSS surveys are:

the Galactic Plane Survey (GPS): 1800 deg^2
the Galactic Clusters Survey (GCS): $>$ 1000 deg^2
the Large Area Survey (LAS): 4000 deg^2
the Deep Extragalactic Survey (DXS): 35 deg^2
the UltraDeep Survey (UDS): 0.76 deg^2

The first 3 of these surveys will be the most useful for galactic astronomy. The GPS covers the northern plane at $|b| < 5°$. The GCS will observe 10 nearby galactic clusters and star forming regions for brown dwarfs. The LAS is a high galactic latitude survey of regions being observed in the optical by the SLOAN survey. Most of these surveys are in the J, H and K bands but the LAS also includes the 'Y band', a new filter sensitive between 0.97 and 1.07 μm wavelengths.

In the remainder of this paper I will outline some of the areas where FMOS (and MOIRCS) might be used to follow up sources detected by these surveys.

2 Brown Dwarfs Science with FMOS

Brown dwarf spectral types are a cooling sequence. The spectral types have been defined using 2MASS and SLOAN sources, (see eg. ref. 1). They range from near M6 soon after formation through the L and T types to later, not yet discovered types at ages of several Gyr. The GCS and GPS will provide fields with the high source densities of brown dwarf candidate suitable for FMOS follow up. These will mostly be relatively warm and young brown dwarfs with M and L spectral types.

The UKIDSS brown dwarf science goals are to measure the IMF in a range of different environments and study brown dwarf formation and kinematics. The GCS will survey 10 nearby clusters at JHK to K=18.4. The younger clusters GCS have high source densities. The GPS will survey half the galactic plane at JHK to K=19. Hundreds of clusters will be detected but most will be quite distant and crowded. FMOS will be invaluable for testing cluster membership. The ratio of contaminating non cluster members to bona fide members projected within a cluster varies widely depending on galactic latitude, distance and extinction. These factors are not always predictable so spectroscopy of a representative sample of sources in many clusters will be essential for measurement of the IMF. The SIRTF Legacy surveys, ASTRO-F surveys and MSX dataset will also provide useful data for identifying brown dwarfs in the mid and far infrared but they will lack the spatial resolution of the UKIDSS surveys and FMOS.

Beyond identifying brown dwarfs, FMOS spectra at 0.9-1.8 μm will also yield effective temperatures, spectral types and surface gravity measurements. Surface gravity is most precisely measured from the equivalent widths of absorption lines of the alkali metals sodium and potassium. The two strong KI doublets in the J band are well suited for observation with FMOS. Surface gravity also has a profound influence on the H band continuum (ref. 2). This a useful feature for identifying members of very young clusters in spectra at low to moderate signal to noise, though it does not provide such precise gravity measurements as the alkali metal lines.

These various observables allow us to locate brown dwarfs on the HR diagram, yielding an age corrected IMF and the star formation history of the cluster in question. (Cluster ages will be determined by main sequence fitting). With a large sample of sources in many clusters it will then become possible to try to understand subtle features such as the effect of metallicity on the spectra.

In the youngest clusters, eg. the Orion Nebula cluster, star formation is still ongoing and circumstellar matter can affect the spectra. For example, scattered light will influence the slope of the continuum and externally excited [SIII] and accretion powered Hydrogen recombination lines will be detected. These provide clues to the accretion rate and status of the youngest 'proto-brown dwarfs'. The large number of FMOS fibres will be invaluable in these very young clusters for subtraction of the highly structured nebulous background.

3 *Chandra* / UKIDSS sources and FMOS

The UKIDSS Galactic Plane Survey will identify infrared counterparts to thousands of *Chandra* and XMM X-ray sources. An example is the infrared follow up to the *Chandra* study of the Galactic Centre (ref. 3). The $\sim$ 800 sources detected in ≈ 1 deg^2 by *Chandra* are likely to be a mixture of CVs, neutron star binaries undergoing Roche lobe overflow from a companion, wind accreting binaries and perhaps active stars. A small number of background AGN are also likely to be present.

The combination of the UKIDSS GPS and FMOS will be needed to identify all the infrared counterparts and obtain spectra to distinguish between the different populations. The galactic centre is entirely obscured from view in the optical, hence the need for FMOS. Deep FMOS spectroscopy will detect accretion signatures from the disc such as HI lines and will also detect and identify the fainter stellar companion in cases where it is not too faint. MOIRCS K band spectra will also be useful for sources which are too reddened for observation at H band.

Other *Chandra* sites for FMOS follow up will include: (1) The *Chandra* Deep Field;

(2) other UKIDSS GPS fields; and (3) nearby spiral galaxies. In all these cases IR spectroscopy is desired to identify the X-ray sources, even if some work can be done at optical wavelengths.

4 High excitation regions

The 0.9-1.8 μm region of the spectrum is poor in low excitation lines but contains many high excitation lines. It is therefore likely that FMOS will be used to study high mass star forming regions, planetary nebulae and supernova remnants. All these environments are highly excited by UV radiation and reradiate in near infrared lines of HeI, HeII, [SIII] and [PII], as well as low excitation lines. Integral field units might be used for some of these studies in future but a sparse sampling of a nebula over a wide field with FMOS would be more valuable than the full sampling of very small fields provided by the present generation of IFUs.

Star formation regions containing O-type stars often have pervasive nebulosity with a wide range of excitation conditions. Analysis of such regions is important to understand the effect of environment on star and brown dwarf formation and the IMF. The excitation is often spatially structured on small scales, so the large number of FMOS fibres would be useful to sample the nebulosity in many locations in a young cluster. Similar observations can also be made of the externally illuminated photoevaporating envelopes seen around young stellar objects closest to the O-type stars (see eg. ref. 4).

5 Conclusions

In summary, FMOS and similar IRMOSes will be essential for the exploitation of data from the UKIDSS Galactic Plane Survey and Galactic Clusters Survey. For Galactic Science optical spectroscopy is of little use. FMOS galactic science will benefit from a synergy of X-ray, near IR and mid-IR data.

References

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