# The FLAIR–DENIS Redshift Survey

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**Abstract:** The DEep Near-Infrared Survey of the southern sky (DENIS) will produce an important by-product: a clean, complete view of the local Universe to $z \sim 0{\cdot}07$ for $10^5$ galaxies. We identify the FLAIR multi-fibre system on the UKST as an extremely competitive facility to undertake follow-up spectroscopy for this sample due to the need to cover wide areas of sky and observe thousands of objects to a relatively bright ($B \leq 17{\cdot}5$) magnitude.

## 1 The DENIS Southern Sky Survey

DENIS is a major survey to map the southern hemisphere in the I ($0{\cdot}8\ \mu$m), J ($1{\cdot}25\ \mu$m) and $K_s$ ($2{\cdot}15\ \mu$m) bands. The ESO $1{\cdot}0$ m telescope has been donated to the DENIS team for this dedicated survey and the project is the European equivalent of the American 2MASS survey. The near-IR camera uses a $256 \times 256$ NICMOS array giving 3 arcsec pixels which are dithered by a microscanning mirror in both RA and DEC for enhanced resolution. The three pass-bands I, J and $K_s$ will be observed simultaneously by means of dichroic mirrors in a stop-stare mode of observation. The DENIS survey began in December 1995 and should be complete by 1999.

## 2 Cosmological Application of the DENIS Survey

Although primarily intended for stellar science through the detection of point sources with fluxes $\geq$1 mJy (e.g. galactic structure studies and the detection of brown dwarf candidates and obscured regions of star formation) an important extra application is the capability to obtain a complete view of the local Universe out to $z \sim 0{\cdot}07$ by virtue of a 'clean' near-IR selected bandpass. Here selected galaxies are less susceptible to extinction in our own Galaxy (e.g. Rieke et al. 1993) and by internal absorption of the host galaxy (e.g. Rix 1993). Samples can be obtained through the Zone of Avoidance whilst the stellar populations of even highly dusty galaxies can be discerned. The total luminosity of a galaxy at 1–2 $\mu$m is thought to be an excellent tracer of the true stellar mass in a galaxy, as it sees through to the 'backbone' of a galaxy, unlike the B band which is biased by the effects of recent star formation. Hence a more complete sample, less biased by star-formation and internal or galactic extinction, should be produced. If one assumes that stellar mass content follows total galaxy mass (including dark matter) then a NIR survey should be a good way of measuring the matter distribution in the local Universe. All the above factors make a J/$K_s$ selected sample an obvious choice for the basis of a new all southern sky galaxy redshift survey being less susceptible to problems biasing optically selected or even IRAS samples.

A detailed map of the local Universe to $z \sim 0{\cdot}07$ and determination of the J ($1{\cdot}25\ \mu$m) or $K_s$ ($2{\cdot}15\ \mu$m) band luminosity function of local galaxies will be a prime aim of the redshift survey. A catalogue of galaxy pairs, groups and clusters can also be established. The effects of galaxy environment and the distribution of galaxies on large scales can also be measured. The complete sample would also provide new estimates of the spatial correlation function to compare with results from the B and far IR selected bands which give too much power on large scales compared with CDM. The story might be different with a clean J or $K_s$ sample, weighted towards the old stellar population, than for a B-selected sample weighted towards the recently star-forming galaxies.

Another major difference between this and other large redshift surveys is that we propose to measure internal velocities (dispersions or rotations) for galaxies in our sample to allow determinations of distances, via the Fundamental Plane or the Tully–Fisher relation, and hence a comprehensive map of the peculiar motions and mass distribution over the southern sky.

## 3 Role of FLAIR: A Major New UKST Survey

A major Franco-Australian collaboration has proposed to use FLAIR, the multi-object fibre spectroscopy system on the UK Schmidt Telescope (UKST) for spectroscopic follow-up of DENIS galaxies. Such a redshift survey of $10^5$ galaxies presents a major observational challenge. Systems like 2dF on the AAT are inappropriate due to the poor match between fibre density on the sky (100 per sq. deg.) and DENIS galaxies (~6 per sq. deg.). Single-object spectroscopy is also incapable of making significant in-roads on competitive time-scales. However, the proposed survey is much better matched to FLAIR's fibre density and field of view. The B-band DENIS limit would be $\sim 17{\cdot}3$ (for typical galaxy B–J colours) which is well within FLAIR's capabilities. The commissioning of a thinned CCD has led to impressive performance gains such that a single FLAIR–DENIS field could be observed in 2 hours (Parker 1996). It is anticipated that 20% of the sky can be covered per annum using 35% of the time on the UKST. This assumes two FLAIR–DENIS fields

per night for the 10 dark nights per lunation (4 hours per night) and one field for the 10 grey nights per lunation (1·5–2 hours per night) and two-thirds clear weather. Although the survey could proceed with the existing semi-manual fibre positioning, it is labour-intensive, messy and time consuming. Major FLAIR upgrades to give more fibres and automatic fibre-positioning would substantially improve the efficiency of the survey, perhaps by a factor of 4. A major push for a more automatic system is under way. Various options are being studied, though a fully automated, off-telescope, pick-place fibre positioning system is the ideal solution.

By the anticipated 1998/99 start date for the FLAIR–DENIS survey, all the major photographic surveys (ER, EJ, SES, I) undertaken at the UKST should be complete. Very considerable amounts of FLAIR time may become available for the FLAIR–DENIS survey, which would constitute a new UKST survey, going on the telescope whenever the conditions are too poor for photography, as well a getting other substantial amounts of allocated time.

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## An Obscured Galaxy Redshift Survey with FLAIR

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A problem for studies of large scale structures in nearby space ($cz < 10,000\ \mathrm{km\,s^{-1}}$) is the presence of the Zone of Avoidance which is so large and wide on the sky that potentially important clusters and voids remain undetected. A prime example was the Ophiuchus cluster discovered by Wakamatsu and Malkan (1981) as a heavily obscured cD cluster close to the Galactic centre region ($l = 0{\cdot}5°$, $b = +9{\cdot}5°$). It is the second brightest X-ray cluster after Perseus. A hidden galaxy survey was performed by visually searching ESO/SERC Sky Survey (R and J) copy films of the region centred at $l = 355°$, $b = +10°$ finding more than 4000 galaxies in six fields. Several irregular clusters adjacent to Ophiuchus were found forming a supercluster which may be connected to the Hercules supercluster by a wall structure parallel to the local supergalactic plane (Wakamatsu et al. 1994). In front of this supercluster, an 'Ophiuchus Void' is suggested ($cz = 4,500\ \mathrm{km\,s^{-1}}$). The Ophiuchus supercluster at $cz = 8,500\ \mathrm{km\,s^{-1}}$ is similar to the Hercules supercluster ($cz = 11,000\ \mathrm{km\,s^{-1}}$), and extends north toward the latter supercluster.

We have used FLAIR, the fibre-spectroscopy system on the UKST (Parker 1996) to study the bridge region between the two superclusters which covers ($16{:}00 \leq \alpha \leq 17{:}20$, $-25° \leq \delta \leq +2{\cdot}5°$) and a void region, 1·5 hour west of a declination zone $-30° \leq \delta \leq -15°$. FLAIR is well matched to the number density (~3/sq. deg.) and magnitude limit ($B \leq 17{\cdot}0$) of the survey galaxies. The region, mostly above $b \sim 15°$, has star densities low enough for FLAIR use without severe crowding or contamination problems. So far 1500 redshifts for obscured galaxies have been obtained. The Ophiuchus supercluster extends at least one field north towards the Hercules supercluster and is surrounded by a diffuse, extended halo $\sim 20° = 30h^{-1}$ Mpc across. A new sparse 'Libra' supercluster candidate is also detected at $cz = 9000\ \mathrm{km\,s^{-1}}$, one field south of the southern edge of the Hercules supercluster. A wall structure is clearly suggested between this and the Ophiuchus supercluster. The proposed 'Ophiuchus–Hercules Wall' formed by a local void in front of, and another behind the Ophiuchus and Libra superclusters, may form a structure as large as the Great Wall both in apparent size ($> 70°$) and physically ($100h^{-1}$ Mpc). These two walls cross perpendicularly near Abell 2199–the northern edge of Hercules supercluster. Any 'true' 3-D orthogonality between the Ophiuchus–Hercules Wall and the Great Wall may be crucial for understanding $0{\cdot}1c$ scale structure whilst this local contrast of galaxy distributions may strongly affect our estimation of the Local Group motion relative to the microwave background.

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## An HI Selected Sample of Galaxies: The HI Mass Function and the Surface Brightness Distribution

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**Abstract:** Results from the Arecibo HI Strip Survey, an unbiased extragalactic HI survey, combined with optical