A census of K-band galaxies from the UKIDSS Large Area Survey

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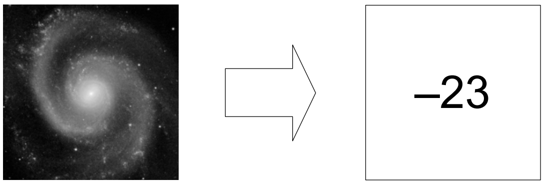
It is possible to learn a lot about a population's history by taking a census. The new near-infrared UKIDSS Large Area Survey (LAS), combined with its optical counterpart, the Sloan Digital Sky Survey, makes it possible to take a census of low-redshift galaxies focussing on the distribution of stellar mass, as revealed by the K-band light. I present some recent results looking at the luminosities and surface brightnesses of galaxies in the LAS.

1. Losing information?

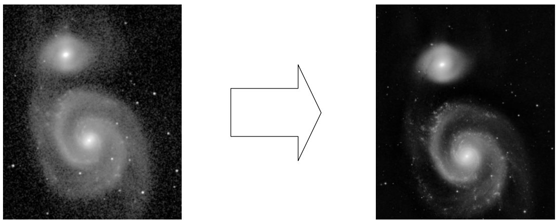


M51a imaged by WFCAM on UKIRT (credit: Cambridge Astronomical Survey Unit)

Galaxies exhibit an astonishing amount of variety and structure. Traditionally, when surveying galaxies, this detail is washed away and the galaxy is reduced perhaps to a single number, for example, its *K*-band absolute magnitude. Then, when quantifying, for example, the number of galaxies per unit volume with a certain absolute magnitude (the **luminosity function**), this is traditionally represented by only three numbers, the Schechter function parameters.

With the advent of large-scale high-resolution galaxy surveys, such as SDSS and UKIDSS, there is no need to discard so much information. A **census** seeks to retain as much information as possible about each galaxy, for example, its colour, surface brightness, radius, concentration and morphology.

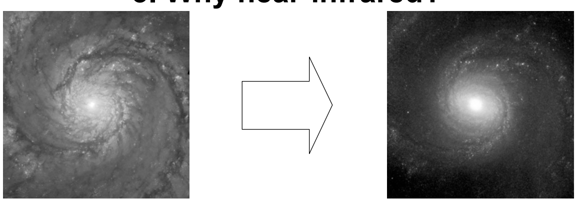
2. Look closely…



M51 from 2MASS (left, Jarrett et al., 2003) and from WFCAM, the camera used for UKIDSS (right, credit: Cambridge Astronomical Survey Unit)

Advances in camera technology have made imaging the sky much quicker, so large-scale surveys are much more feasible. This new power may be used to probe galaxies at higher redshift, but there are certain advantages in low-redshift surveys. First, the surface brightness of galaxies drops as $(1+z)^4$, so low-surface brightness galaxies are likely to be detected only at low redshift. Secondly, it is now possible to undertake detailed structural surveys of low-redshift galaxies. And, thirdly, low-redshift surveys are not plagued with the selection biases of higher-redshift surveys.

3. Why near-infrared?

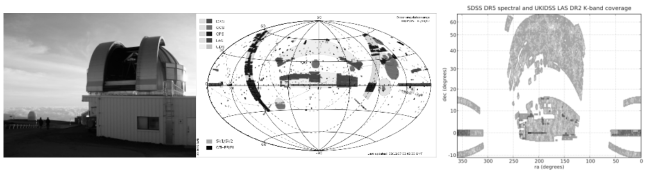


M51a, optical (left) and NIR (right), credit: Travis Rector & Monica Ramirez (NOAO)

In taking a census of galaxies, our primary interest is usually the distribution of mass. Optical light is a relatively poor tracer of the stellar mass of galaxies, being dominated by blue light from energetic young stars. Near-infrared light (1–2 μm), however, is a much better tracer of the stellar mass of a galaxy, since the mass-to-light ratios of young (blue) and old (red) stars are very similar in the near-infrared. In addition, dust and *K*-corrections are much less of a problem in the NIR than optical.

A census of galaxies should ideally combine observations taken at several different wavelengths, but it makes sense to build such an investigation on a sample selected in the the near-infrared (e.g., *K*-band).

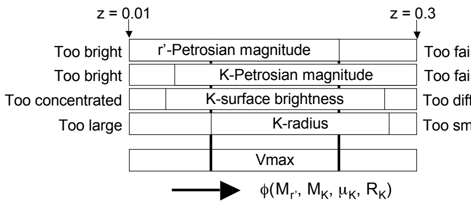
4. UKIRT Infrared Deep Sky Survey (UKIDSS)



UKIDSS (www.ukidss.org) is the true successor to 2MASS (the Two-Micron All-Sky Survey), and the first of a new generation of near-infrared surveys. Based at the UK Infra-Red Telecscope (UKIRT) in Hawaii, UKIDSS will complement the southern-hemisphere telescope, VISTA, which is being constructed in Chile. Both UKIDSS and VISTA are European (ESO) projects in which the UK is playing a leading role.

UKIDSS consists of five distinct surveys of various areas and depths, optimized for Galactic or extra-Galactic targets. This work uses the Large Area Survey (LAS), the near-infrared counterpart to the optical Sloan Digital Sky Survey (www.sdss.org), adding *YJHK* photometry to the optical *ugriz* photometry and spectroscopy. With some 20,000 galaxies in the current sample (LAS DR2 with SDSS DR5 redshifts), this points towards a final sample of around 400,000 galaxies by the end of 2009.

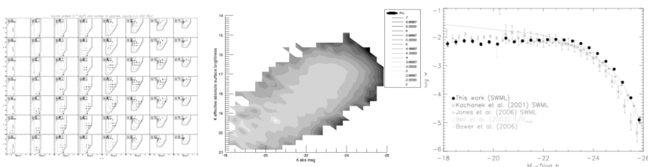
5. How many galaxies *can't* you see?



When estimating the number of galaxies of a certain type per unit volume, it is necessary to know (1) the number of galaxies of that type in the sample and (2) the volume probed by the sample. Once the galaxies have been detected, the more important and challenging task is to take account of the galaxies that *can't* be seen in the survey.

There are many reasons why a galaxy might not be detected reliably. It may be too faint, too bright, too diffuse, too large, too small or too close to a bright star. Estimating values for these limits reduces the sample to 16,452 galaxies. For each of these galaxies, the volume within which that galaxy could have been observed is estimated using the method illustrated above.

6. Space density of galaxies



The multivariate (four-dimensional) equivalent of the luminosity function is estimated using two different methods: $1/V_{max}$ and SWML. Results from the SWML method are shown above (details available from Anthony Smith). The four-dimensional space density (left) is integrated over two dimensions (the *r*-band absolute magnitude and the *K*-band radius) to give the bivariate brightness distribution (centre) in *K*-band luminosity and *K*-band surface brightness. The shaded region shows the (log) number density of galaxies (number of galaxies per h^{-3}Mpc^3). (Note that this process of marginalizing over certain dimensions will introduce a certain error into the final results.)

The bivariate distribution can then be integrated to give the *K*-band luminosity function (right), which is shown with previous results for comparison.