The 2dF Galaxy Redshift Survey

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1 Survey Design

The 2dF Galaxy Redshift Survey now in progress is using the Two Degree Field 400-fibre spectrograph (2dF) on the Anglo-Australian Telescope to obtain high-quality spectra and redshifts for 250,000 galaxies. These galaxies are a magnitude-limited sample brighter than b_J=19.5 (extinction-corrected) drawn from a revised and extended version of the APM galaxy catalogue (Maddox et al. 1990). The bright survey will cover an area of 1700 square degrees selected from both the southern galactic hemisphere APM galaxy survey and its extension into the north galactic hemisphere equatorial region. The approximate arrangement of 2dF survey fields is shown in Figure 1. This bright survey will be supplemented by a faint survey of 10,000 galaxies to R=21 based on APM scans of deep UK Schmidt Telescope films obtained for selected regions. The faint survey is carried out in an over-ride mode making use of the best observing conditions.

2 Goals of the Survey

The survey will address a variety of fundamental problems in galaxy formation and cosmology. The main scientific goals include:

1. Accurate measurements of the power spectrum of galaxy clustering on scales of up to a few hundred Mpc, allowing direct comparisons with microwave background anisotropy measurements of fluctuations on the same spatial scales.

2. Measurements of the distortion of the clustering pattern in redshift space, providing constraints on the cosmological density parameter Ω and the spatial distribution of dark matter.

3. A determination of variations in the spatial and velocity distributions of galaxies as a function of luminosity, type and star-formation history, providing important constraints on models of galaxy formation.

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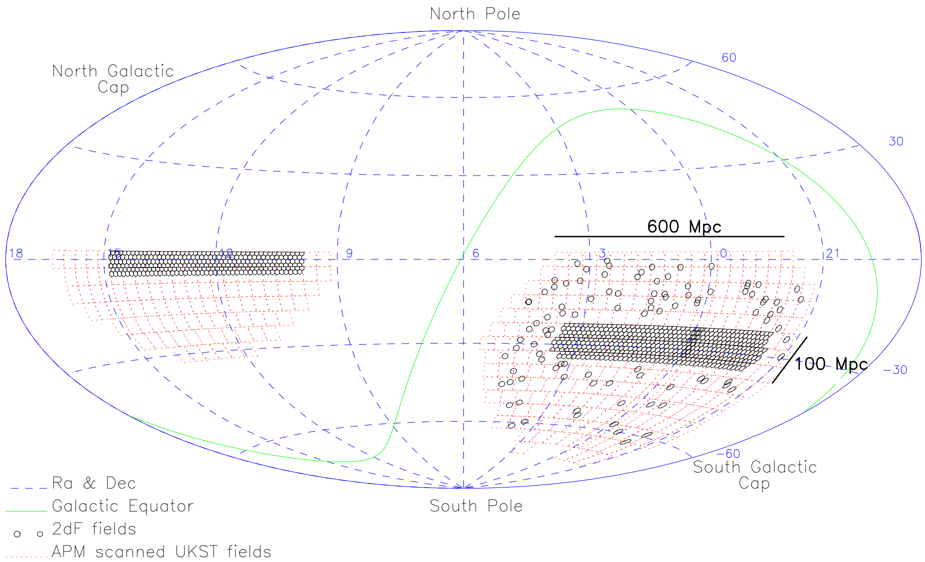

Fig. 1. The 2dF survey fields (small circles) superimposed on the APM survey area (dotted outlines of Sky Survey plates). There are approximately 140,000 galaxies in the 75°×12.5° South Galactic Hemisphere strip centred on the South Galactic Pole, 70,000 galaxies in the 65°×7.5° North Galactic Hemisphere equatorial strip, and 40,000 galaxies in the 100 random 2dF fields scattered over the entire southern region of the APM galaxy survey.

4. Measurements of the evolution of the galaxy luminosity function, clustering amplitude and star formation rates out to a redshift of $z{\sim}0.5$. This will be accomplished by combining the bright $b_J{<}19.5$ survey with the faint R<21 survey, which is comparable in size to the largest current local surveys.

5. Investigations of the morphology of galaxy clustering and the statistical properties of the fluctuations—for example, whether the initial fluctuations are Gaussian as predicted by inflationary models of the early universe.

6. A study of clusters and groups of galaxies in the redshift survey, in particular the measurement of infall in clusters and dynamical estimates of cluster masses at large radii.

7. Application of novel techniques to classify the uniform sample of 250,000 spectra obtained in the survey, thereby obtaining a comprehensive inventory of galaxy types as a function of spatial position within the survey.

3 Survey Status

As of 30 January 1998 we have obtained ~8000 redshifts for the survey. The rate at which redshifts are gathered will increase rapidly as 2dF is brought up to full operational speed. The survey can be completed within two years of

2dF achieving nominal observing efficiency. We currently expect to complete the survey by the end of 1999.

Two example spectra from the survey are shown in Figure 2. One is a b_J=19.2 emission-line galaxy at z=0.067 and the other is a b_J=19.3 absorption-line galaxy at z=0.246. The quality target for the survey spectra is a S/N of at least 10 per 2-pixel resolution element (FWHM≈9Å); most spectra will easily exceed this target.

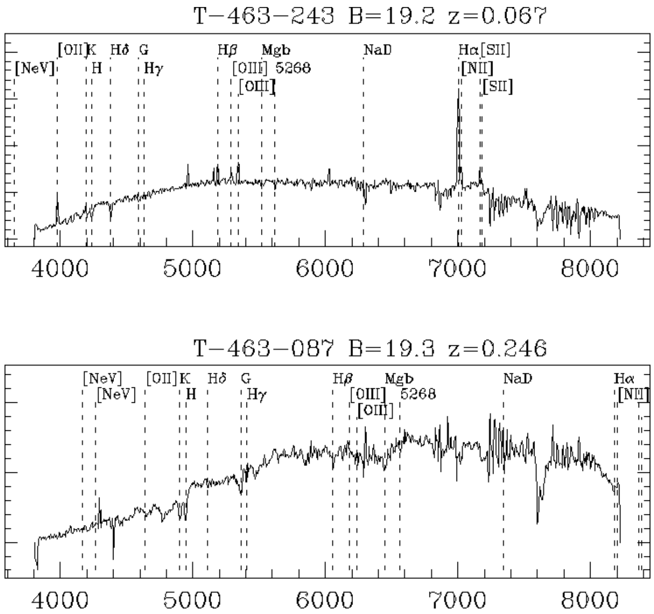

Fig. 2. Example spectra from the survey: a b_J=19.2 emission-line galaxy at z=0.067 and a b_J=19.3 absorption-line galaxy at z=0.246.

This minimum S/N permits reliable automatic spectral classification and redshift measurement. Employing both a standard cross-correlation and line-fitting code and a new code which uses Principal Component Analysis and χ^2-fitting to simultaneously classify the spectrum and measure its redshift (Glazebrook et al. 1997), we find we achieve a very high level of reliability. A comparison of the redshifts obtained from these codes with redshifts determined via visual inspection shows a very low level of failures in the automatic algorithms. The success rate in identifying redshifts for survey galaxies is currently 90–95%; the goal is to achieve an overall success rate in excess of 95%.

4 Preliminary Results

The survey is still in its infancy, with only ~8000 redshifts (3% of the total) measured to date. Some preliminary results can, however, provide a hint of the

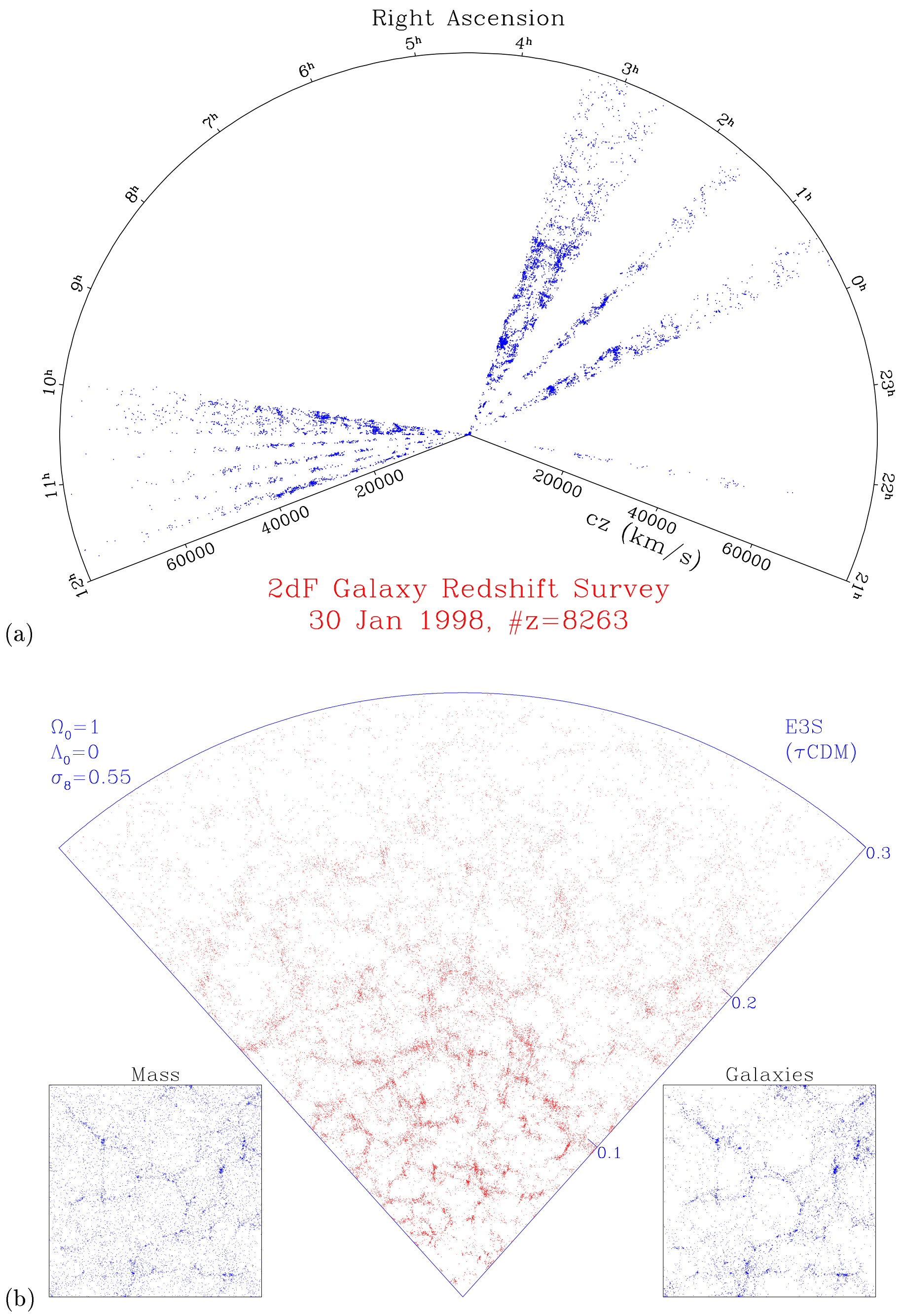

Fig. 3. (a) A redshift slice for the galaxies observed to date, combining northern and southern strips and including ∼8000 galaxies (∼3% of the full sample). (b) A cone plot for a mock 2dF redshift survey from Cole et al. (1998).

power and scope of the full survey.

Figure 3a is a cone plot for these ~8000 galaxies combining both the northern and southern strips. Note the highly incomplete filling of the slice by the 2dF fields so far observed. For comparison, Figure 3b shows a 90°×3° slice through a mock 2dF survey based on a CDM N-body simulation and a recipe for galaxy biasing (see Cole et al. 1998).

Figure 4 shows the combined redshift distribution in comparison to the predicted distribution in a homogeneous universe. There is clearly strong clustering, but the irregular distribution on the sky of the fields we have observed so far makes quantitative analysis difficult.

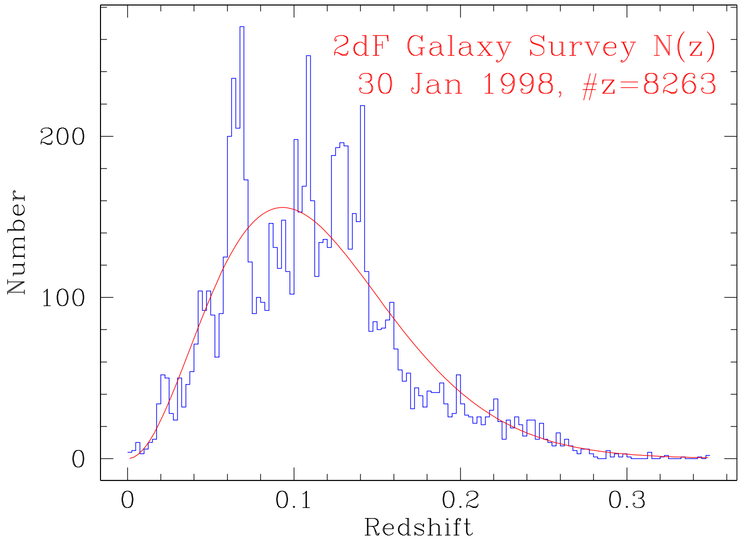

Fig. 4. A preliminary redshift distribution from the 2dF survey. The smooth curve is the predicted redshift distribution neglecting clustering.

Although so far we have observed too few fields to effectively address questions of large-scale structure, we do have a sufficiently large sample of redshifts to begin to look at the properties of local galaxies. Figure 5 shows the galaxy luminosity function at a mean redshift of z=0.1. This preliminary determination uses a single global K-correction and is normalized by the number counts from the APM input catalogue, so that the shape and normalization may change in the final analysis. Note however that we are achieving a good determination of the luminosity function 5 magnitudes below L^* even with this small subset of the survey. The LF is generally well represented by a Schechter function with $M^* \approx -19.5$, $\alpha \approx -1.1$ and $\phi^* \approx 0.02$. With the full sample we should be able to tightly constrain the faint end of the local luminosity function for each morphological or spectral type and determine the variation in the luminosity function with local density.

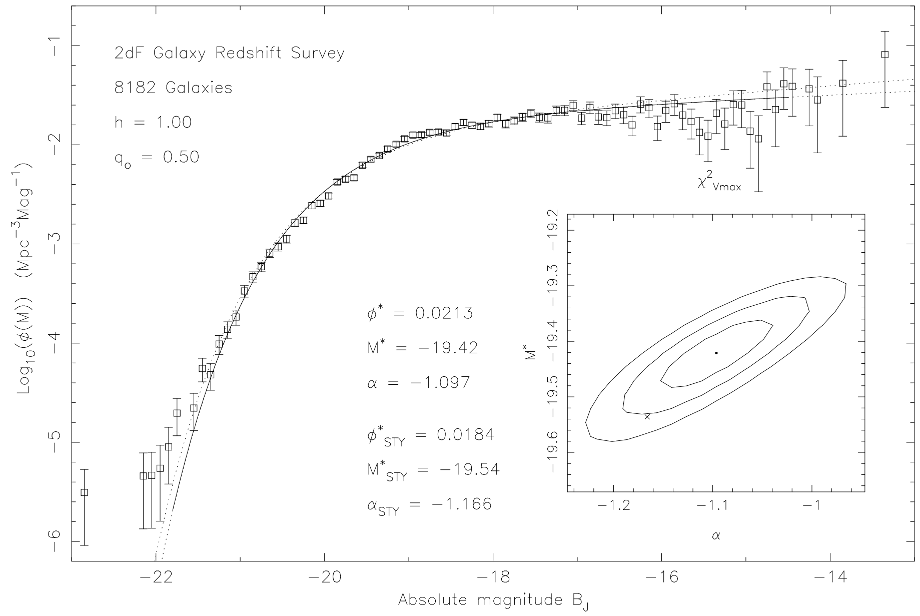

Fig. 5. A preliminary galaxy luminosity function from the 2dF survey using mean K-corrections and normalised to the APM number counts. The points are the $1/V_{max}$ LF, the solid curve is the χ^2 fit of a Schechter function to the points and the dotted curve is the STY fit of a Schechter function. The parameters of these fits are given on the figure. The inset shows the 1, 2 and 3-σ contours of the χ^2 fit in M^* and α; the cross marks the M^* and α obtained from the STY fit.

Further details regarding the 2dF survey can be found in Colless (1997) and Colless & Boyle (1998). Up-to-date information is posted on the WWW at `http://msowww.anu.edu.au/~colless/2dF/`.

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