

arXiv:astro-ph/0306581 v1 27 Jun 2003

# The 2dF Galaxy Redshift Survey: Final Data Release

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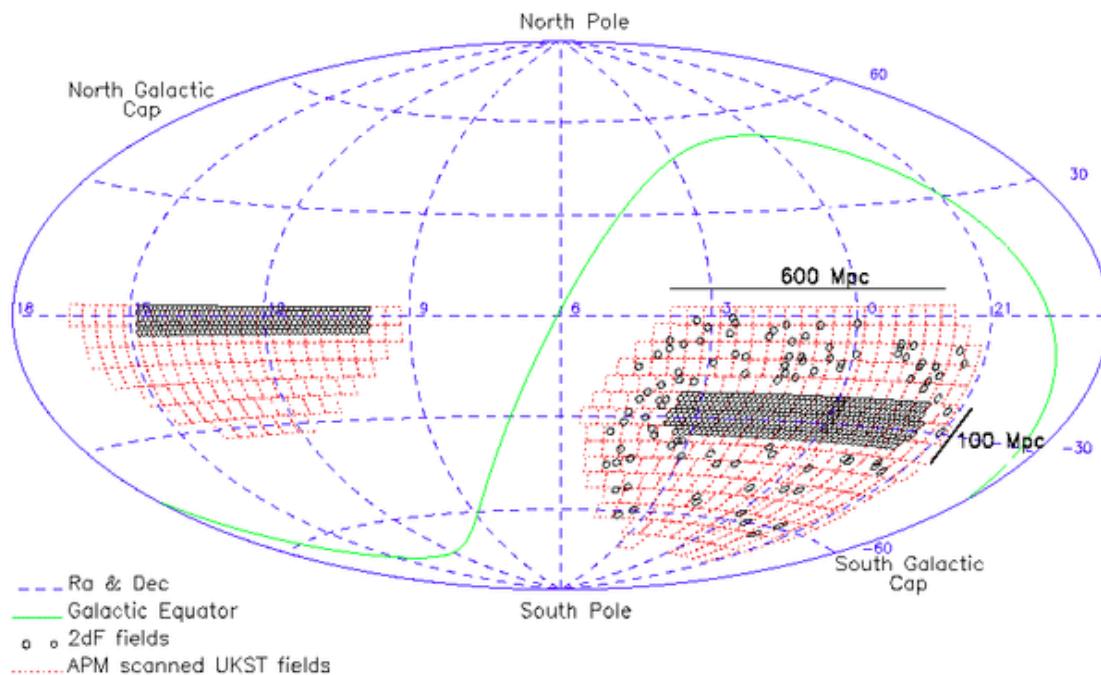
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## 1 Introduction

The 2dF Galaxy Redshift Survey (2dFGRS) is a major spectroscopic survey taking full advantage of the unique capabilities of the 2dF facility built by the Anglo-Australian Observatory. The 2dFGRS is integrated with the 2dF QSO survey.

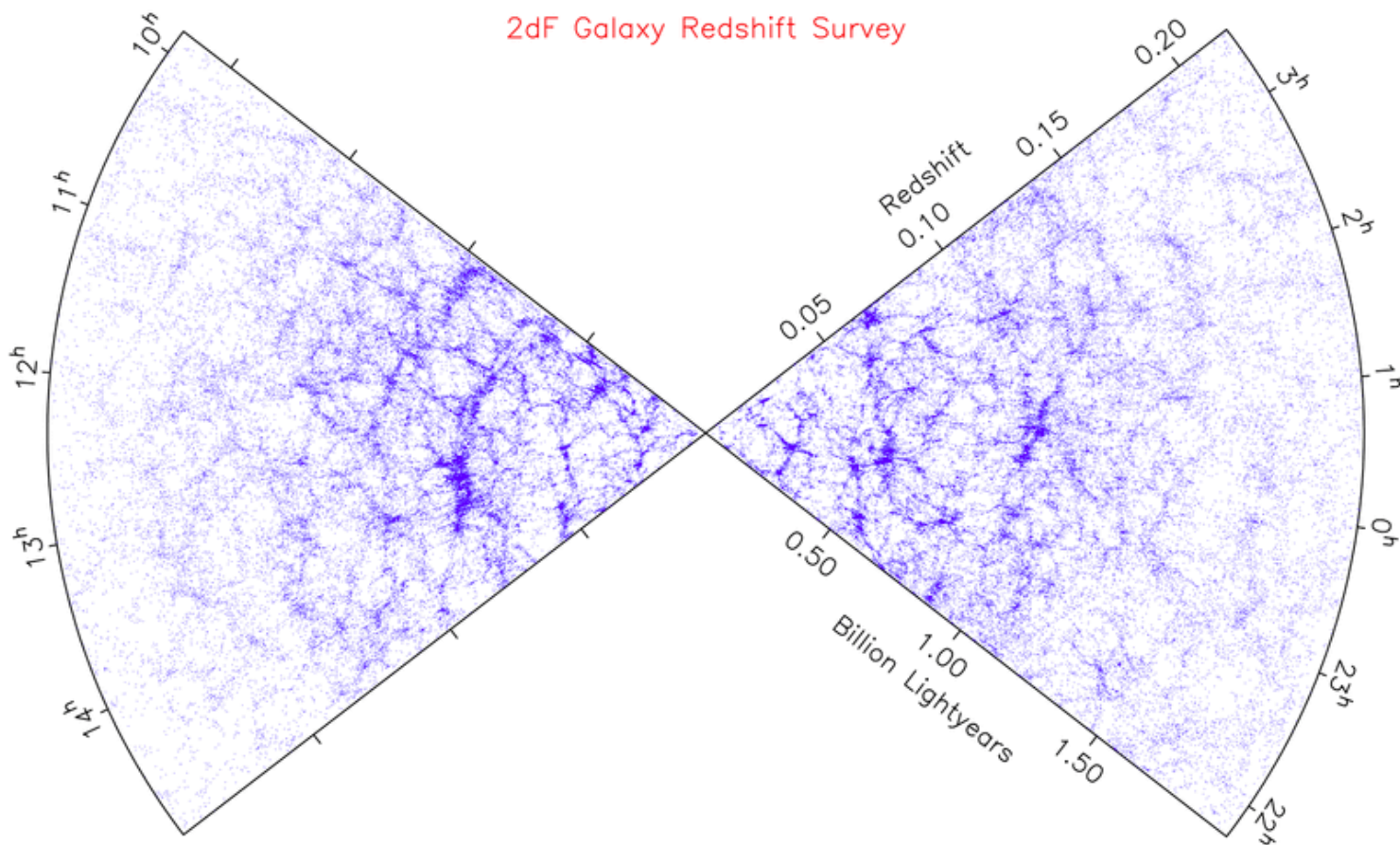
The 2dFGRS obtained spectra for 245591 objects, mainly galaxies, brighter than a nominal extinction-corrected magnitude limit of  $b_j=19.45$ .

Reliable (quality $\geq 3$ ) redshifts were obtained for 221414 galaxies. The galaxies cover an area of approximately 1500 square degrees selected from the extended APM Galaxy Survey in three regions: an NGP strip, an SGP strip and random fields scattered around the SGP strip. The arrangement of survey fields is shown below.



The 2dFGRS survey and its database are described in detail in Colless et al. (2001), with additional documentation and updates provided on the WWW at <http://www.mso.anu.edu.au/2dFGRS/>. The figure below shows the map of the galaxy distribution produced from the completed survey (other versions of this figure in various image formats are accessible from the WWW page).

## 2dF Galaxy Redshift Survey



The survey has been used to address a variety of fundamental problems in galaxy formation and cosmology. The results emerging from the survey to date include:

- An accurate measurement of the power spectrum of galaxy clustering on scales up to  $300h^{-1}$  Mpc, allowing precise determinations of the total mass density of the universe and the baryon fraction (Percival et al. 2001).
- Measurements of the distortion of the clustering pattern in redshift space, providing independent constraints on the total mass density and the spatial distribution of dark matter (Peacock et al. 2001 and Hawkins et al. 2003).
- A strong new upper limit on the total neutrino mass (Elgaroy et al. 2002).
- In combination with observations of the cosmic microwave background (CMB), precise measurements of the Hubble constant and the baryon density, evidence for a non-zero cosmological constant (dark energy), and constraints on the equation of state of the dark energy (Efstathiou et al. 2002 and Percival et al. 2002).
- The first direct measurements of the galaxy bias parameter, both from higher-order correlations in the galaxy distribution (Verde et al. 2002) and from comparison with the CMB power spectrum (Lahav et al. 2002).
- A characterization of the galaxy luminosity function in both the optical (Norberg et al. 2002) and near-infrared (Cole et al. 2001), with the former yielding the mean current star-formation rate and the latter the stellar mass function of galaxies.
- The distribution of galaxies as a joint function of total luminosity and central surface brightness (Cross et al. 2001).
- The luminosity functions for galaxies with different spectral types, both in the field (Folkes et al. 1999 and Madgwick et al. 2001) and in clusters (De Propris et al. 2003).
- The variation in clustering properties of galaxies as functions of luminosity (Norberg et al. 2002) and spectral type (Madgwick et al. 2003).
- Constraints on the cosmic star-formation history from the mean galaxy spectrum in the local universe (Baldry et al. 2002) and the environmental dependence of star-formation rates of galaxies around clusters (Lewis et al. 2002).
- The properties and luminosity functions of radio sources of various types (Sadler et al. 2002 and Magliocchetti et al. 2002).
- The properties of previously-identified clusters of galaxies in the survey, and dynamical estimates of the cluster masses (De Propris et al. 2001).

Further results emerging from the 2dFGRS are described in other [publications](#) of the 2dFGRS team.

The final release dataset comprises the following elements:

- The input [photometric catalogues](#) (source catalogues) for the full 2dFGRS survey, containing data for 382323 objects, together with related material.
- The [spectroscopic catalogues](#) for 245591 objects, containing the spectroscopic parameters such as redshifts and spectral types.
- The [mSQL database](#), which allows searching and subsetting of the public release data, and provides access to the FITS files containing the spectra as well as all the other photometric and spectroscopic parameters.
- The [survey masks](#) and [mask software](#) for determining whether a given position is in the survey region, and the survey magnitude limit and redshift completeness at that position; also [selection software](#) for extracting various types of subsamples and creating corresponding mock catalogues.
- Documentation, both [on-line](#) and through links to [survey publications](#).
- Additional material such as images, movies and stills, media reports and links to related topics.

## 2 ADDITIONS AND CHANGES

The following are the main additions and changes to the survey database between the 100k Release of 30 June 2001 and the Final Release of 30 June 2003:

- Input source catalogue: The input source catalogue has been cleaned up by removing the superfluous 'supplementary' sources (additional sources fainter than the spectroscopic survey limit) that were included in the 100k release, and deleting 6224 artifacts identified by visual examination of the postage stamp images - see the [database description](#). The final source catalogue consists of 382323 objects.
- Additional photometry: In addition to the original APM  $b_J$  photometric parameters for each source, there are now also SuperCosmos  $b_J$  and  $r_F$  photometric parameters - the new parameters are listed in the [database description](#). The WWW database offers postage stamp images from APM and both SuperCosmos bands (only the APM images are available on the DVDs).
- Photometric calibration: The photometric calibration of the 2dFGRS source catalogue has been further refined since the 100k release through comparisons with both SuperCosmos and SDSS - see the [summary of the calibrations](#).
- Additional spectroscopy: The main change since the 100k release is that there are now spectroscopic observations and parameters for 245591 sources, and reliable (quality $\geq$ 3) redshifts for 221414 galaxies.
- Masks and selection code: The [survey masks](#) have been updated for the final sample, and now fully implement the procedures described in Colless et al. (2001) and Norberg et al. (2002). A new [code](#) is available for selecting various types of subsamples, and for generating corresponding mock, unclustered catalogues.
- Publications: There are now many publications giving the major results from the 2dFGRS - see the [publication list](#) for details.
- Images and movies: A large number of images (and some movies) showing the survey and the main science results, along with some movies, are available on the WWW pages.

### 3 DATABASE DESCRIPTION

The 2dFGRS database consists of three main components:

1. [A set of FITS files](#), one per object in the source catalogue (the input photometric catalogue), that contains every piece of information about each object from the source catalogue, spectroscopic observations and subsequent analysis.
2. [A Mini SQL \(mSQL\) database](#), that contains all of the parameters for each object and allows complex searching and subsetting of the survey objects, and the retrieval of selected subsets of spectra and images.
3. [A WWW interface](#), that provides a number of different modes for querying the mSQL database and a variety of ways for returning the results of such queries.

This overview gives a basic introduction to each of these three database components. Further information can be found in Colless et al. (2001), which describes the 100k data release. Note, however, that the final release database includes changes and additions to the 100k database, as described below.

#### 3.1 Object FITS Files

There are 382323 target objects in the final FITS database, each with its own FITS file. Each object in the survey source catalogue has been given a serial number (`SEQNUM`), and the name of the FITS file for that object is this serial number. The serial numbers for objects in the SGP strip are 1-193550, for objects in the NGP strip 193551-332694, and for objects in the random fields 332695-389713.

Note that: (i) The 'supplementary' objects with serial numbers  $>389713$  that were included in the 100k release have now all been deleted; these were additional objects fainter than the nominal survey limit, and were never observed. (ii) The objects in random field 859 were improperly named, so, as this field was never observed, the 1166 sources in the field have been deleted. (iii) Visual inspection of the source images during the initial construction of the source catalogue identified 4604 sources as artifacts; these have now been deleted. (iv) A final visual check of problematic objects selected by comparing the APM and SuperCosmos source lists (see below) identified a further 1620 sources as artifacts; these have also been deleted. These deletions mean that the source catalogue in the final release is significantly cleaner than that in the 100k release.

Each FITS file has a primary part which contains all the source catalogue data about the object (as FITS keywords) and a Digital Sky Survey sky chart (postage stamp image) of the objects. The WWW version of the database also contains SuperCosmos  $b_J$  and  $r_F$  postage stamp images (these images are omitted from the DVD version to conserve space, although the SuperCosmos parameters are present in both versions). Subsequent extensions of the FITS file contain the spectral observations and parameters obtained for the object, appended in chronological order. Each spectrum extension contains the spectrum of the object, the variance (error) array for the object spectrum, the spectrum of the mean sky that was subtracted from the object spectrum, and FITS keyword data giving information about the spectroscopic observation and derived parameters such as the redshift and spectral quality. Many targets contain multiple spectrum extensions corresponding to multiple observations.

[Table 1](#) lists all the FITS keywords present in the primary part (extension 0) of the FITS files; [Table 2](#) lists all the keywords present in spectrum extensions 1..`spectra`. The tables give the names of the keywords, example values, and the keyword descriptions.

The first set of photometric parameters are from APM scans of the Southern Sky Survey  $b_J$  plates, and are the primary photometric data on which the 2dFGRS was based. Photometric parameters with FITS keywords prefixed `SB` and `SR` are from SuperCosmos scans of, respectively, the  $b_J$  and  $r_F$  Southern Sky Survey plates.

In order to remove artifacts from the source catalogue and to flag other problematic cases, 10812 sources (about 3% of the total) were selected for visual examination of their images based on various criteria: 1656 objects with no SuperCosmos source matching the APM position, 4377 objects with a poor match between the APM and SuperCosmos positions and/or magnitudes, another 1321 objects with anomalous colours, and finally all 3458 bright objects with SuperCosmos magnitude  $b_J < 16$ . These objects' images were individually examined and the `VISCHECK` classification parameter set as follows: 0 = not examined (373131 sources), 1 = galaxy (5283 sources), 2 = star (114 sources), 3 = merger (3102 sources), 4 = in bright star halo (377 sources), 5 = artifact (1620 sources), 6 = other (316 sources). In addition, the `VISCOMM` parameter gives comments in some cases (and is mandatory for 'other' classifications). The 1620 objects classified as artifacts were deleted from the database; all 9192 other sources are retained.

Table 1: FITS keywords for the primary image (extension 0)

Keyword	= Value	/ Description
SIMPLE	x	T / file does conform to FITS standard
BITPIX	x	16 / number of bits per data pixel
NAXIS	x	2 / number of data axes
NAXIS1	x	49 / length of data axis 1
NAXIS2	x	49 / length of data axis 2
EXTEND	x	T / FITS dataset may contain extensions
BSCALE	x	1.0000 / REAL = (FITS * BSCALE) + BZERO
BZERO	x	0.0000 / Bias
SEQNUM	=	100100 / Sequence number : Database Primary Key
NAME	=	'TGS469Z164' / 2dFgg assigned name
IMAGE	x	'SKYCHART' / Existence of postage stamp image
RA	=	0.7943429758 / RA in radians : 3 2 3.00
DEC	=	-0.5475286941 / Dec in radians : -31 22 15.9
APMEQNX	=	1950.00 / Equinox of RA and Dec
BJSEL	=	18.858 / final bj mag used in the object selection
PROB	=	2335.4 / psi classification parameter
PARK	=	0.910 / k classification parameter
PARMU	=	0.187 / mu classification parameter
IGAL	=	1 / final class flag (equals 1 for a galaxy)
JON	=	-1 / eyeball class flag
ORIENT	=	91.0 / orientation in degrees clockwise from E-W
ECCENT	=	0.270 / eccentricity
AREA	=	308.0 / isophotal area in pixels
X_BJ	x	2918.7 / plate x_bj in 8 micron pixels
Y_BJ	x	9123.1 / plate y_bj in 8 micron pixels
DX	x	43.0 / corrected difference (x_bj - x_R)*100
DY	x	49.0 / corrected difference (y_bj - y_R)*100
BJG	=	18.920 / bj without extinction correction
RMAG	x	10.35 / unmatched apm "total" mag
PMAG	x	10.53 / unmatched raw apm profile integrated mag
FMAG	x	8.72 / unmatched raw apm 2" profile integrated mag
SMAG	x	10.74 / unmatched raw stellar mag (from APMCAL)
REDMAG	x	/ unmatched raw red stellar mag (from APMCAL)
IFIELD	=	417 / ukst field
IGFIELD	x	2007 / galaxy number in this field
REGION	=	'S417' / GSSS Region name
OBJEQNX	=	2000.00 / Equinox of the plate reference frame
OBJRA	=	0.8034094522 / RA in Radians : 03 04 07.673
OBJDEC	=	-0.5441390223 / Dec in Radians : -31 10 36.73
PLTSCALE	x	67.2000 / Plate Scale in arcsec per mm
XPIXELSZ	x	25.2844500 / X pixel size in microns
YPIXELSZ	x	25.2844500 / Y pixel size in microns
OBJPLTX	x	7970.86 / Object X on plate (pixels)
OBJPLTY	x	4148.11 / Object Y on plate (pixels)
DATAMAX	x	14431 / Maximum data value
DATAMIN	x	4011 / Minimum data value
BJSELOLD	=	18.96 / original bj mag used in the object selection
BJG_OLD	=	19.01 / original bj without extinction correction
BJSEL100	=	18.93 / bj mag used in the object selection (100k)
BJG_100	=	18.99 / bj without extinction correction (100k)
GALEXT	=	0.062 / galactic extinction
VISCHECK	=	0 / visual check flag
VISCOMM	=	' ' / visual check comments
SBFIELD	x	'417' / Sky survey field number
SBRA	=	46.032062700000 / Object RA (J2000.0)
SBDEC	=	-31.176815800000 / Object declination (J2000.0)
SBBJMAG	=	18.836 / UK-J (Bj) magnitude
SBAREA	=	254 / Total area
SBAI	=	7927 / Weighted semi-major axis
SBBI	=	6103 / Weighted semi-minor axis
SBPA	=	8 / Celestial position angle
SBCLASS	=	1 / Classification flag
SBSIGMA	=	22.668 / profile classification statistic
SBBLEND	=	0 / Deblending flag
SBQUAL	=	0 / Quality flag
SBAPM	=	1 / APM-Supercosmos Bj-band match classification
SRFIELD	x	'417' / Sky survey field number
SRRA	=	46.031963000000 / Object RA (J2000.0)
SRDEC	=	-31.176771700000 / Object declination (J2000.0)
SRRMAG	=	17.188 / UK-J (R) magnitude
SRAREA	=	249 / Total area
SRAI	=	7467 / Weighted semi-major axis
SRBI	=	6317 / Weighted semi-minor axis

```

SRPA      =          13 / Celestial position angle
SRCLASS   =          1 / Classification flag
SRSIGMA   =        16.574 / profile classification statistic
SRBLEND   =          0 / Deblending flag
SRQUAL    =          0 / Quality flag
SRSB      =          1 / Supercosmos R vrs Bj match classification

```

Table 2: FITS keywords for the spectra (extensions 1..spectra)

Keyword	= Value	/ Description
XTENSION	x 'IMAGE'	/ IMAGE extension
BITPIX	x -32	/ number of bits per data pixel
NAXIS	x 2	/ number of data axes
NAXIS1	x 1024	/ length of data axis 1
NAXIS2	x 3	/ length of data axis 2
PCOUNT	x 0	/ required keyword; must = 0
GCOUNT	x 1	/ required keyword; must = 1
CRVAL1	x 5802.8979492	/ Co-ordinate value of axis 1
CDELTA1	x 4.3103027344	/ Co-ordinate increment along axis 1
CRPIX1	x 512.0000000000	/ Reference pixel along axis 1
CUNIT1	x 'Angstroms'	/ Units for axis 1
EXTNAME	x 'SPECTRUM'	/ 2dFGRS spectrum
OBSNAME	= 'TGS469Z164'	/ Observed object name
OBSRA	= 0.7943429758	/ Observed RA
OBSDEC	= -0.5475286940	/ Observed Dec
MATCH_DR	= 0.0000	/ Position match dr in arcsec
Z	= 0.178876	/ raw measured redshift
Z_HELIO	= 0.178860	/ heliocentric corrected redshift
QUALITY	= 5	/ redshift measurement quality
ABEMMA	= 1	/ redshift source abs1 emm2 man3
NMBEST	= 0	/ number emission lines for best z_em
NGOOD	= 0	/ number of good emission lines
Z_EMI	= -9.9990	/ emission redshift
Q_Z_EMI	= 0	/ emission redshift quality
KBESTR	= 2	/ x-correlation template
R_CRCOR	= 15.5600	/ x-correlation peak
Z_ABS	= 0.1789	/ x-correlation redshift
Q_Z_ABS	= 3	/ x-correlation quality
Q_FINAL	= 3	/ Suggested quality for redshift
IALTER	= 0	/ No idea
Z_COMM	= ' ' /	Observers Comment
THPUT	= 0.96613	/ Fibre Throughput
SPFILE	= 'sgp469_991104_1z.fits'	/ 2dF reduced data file
PLATE	= 1	/ 2dF plate number
PIVOT	= 302	/ 2dF pivot number
FIBRE	= 58	/ 2dF fibre number
OBSRUN	= '99OCT'	/ Observation run
GRS_DATE	= '991104'	/ 2dF YYMMDD observed date
UTDATE	= '1999:11:04'	/ UT date of observation
SPECTID	= 'A'	/ 2dF spectrograph ID
GRATID	= '300B'	/ 2dF grating ID
GRATLPM	= 300	/ 2dF grating line per mm
GRATBLAZ	= 'COLLIMATOR'	/ 2dF grating blaze direction
GRATANGL	= 25.30000	/ 2dF grating angle
LAMBDA	= 5782.700	/ Central wavelength
CCD	x 'TEKTRONIX_5'	/ CCD ID
CCDGAIN	x 2.790	/ CCD inverse gain e/ADU
CCDNOISE	x 5.200	/ CCD read noise (electrons)
OBJX	= 196833	/ 2dF object x position
OBJY	= 10401	/ 2dF object y position
OBJXERR	= 6	/ 2dF object x position error
OBJYERR	= 14	/ 2dF object y position error
OBJMAG	= 18.96	/ 2dF object magnitude
THETA	= 4.526	/ 2dF fibre angle
PTRTYPE	= 'P'	/ 2dF ptrtype
PID	= 0	/ 2dF pid
OBSFLD	= 'sgp469'	/ 2dF observed field number
NCOMB	= 3	/ Number of frames combined
REFRUN	= 31	/ AAT Run number of reference frame
UTSTART	x '16:37:59.48'	/ UT start of exposure of reference run
UTEND	x '16:57:59'	/ UT end of exposure of reference run
REFEXP	= 1200.0	/ Exposure time (secs) of reference run
REFHASTA	x '36.0726399999999982'	/ HA at start of exposure of reference run
REFHAEND	x '41.08118999999999943'	/ HA at end of exposure of reference run
SNR	= 2.0299999E+01	/ Median signal-to-noise ratio per pixel
ETA_TYPE	= -2.5934000E+00	/ Eta spectral type (2dF defined)

SEEING = 3.0000000E+00 / Seeing (2dF calculated)

### 3.2 mSQL Parameter Database

The mSQL database (see Jepson & Hughes 1998) can be thought of as a table. The rows of the table are labelled by the unique object serial number (`serial`, identical to the parameter `SEQNUM` in the primary extension of the FITS file) and the extension number (`extnum`). There are multiple rows for each target object corresponding to each of the extensions in the object's FITS file: the first row corresponds to the primary FITS extension (extension 0), while subsequent rows correspond to the spectrum extensions 1..`spectra`. The columns of the table correspond to the object parameters, and are labelled by the name of the corresponding keyword. *N.B. case is significant in these keywords.*

The object serial numbers (`serial`) provide the primary database key, but the objects are also indexed by their unique survey name (`name`, identical to the parameter `NAME` in the primary extension of the FITS file), which has the format `TGhfffZnnn`, where `h` is the hemisphere (`N` for the NGP strip and `S` for the SGP strip and random fields), `fff` is the number of the primary field to which the object is assigned and `nnn` is the number of the galaxy within that field.

Note that the observed name of the object (parameter `OBSNAME` in each spectrum extension) is the same as `name` (or `NAME` in the primary extension of the FITS file) except that: (i) if the field in which the object is observed (given by `OBSFLD`) is an overlapping field rather than its primary field (given by `fff`), then the first character of the name is changed from `T` to `X`; and (ii) if the object has been flagged as a possible merger, then the second character of the name is changed from `G` to `M`.

The first row for each object (`extnum=0`) contains the source catalogue data and the basic spectroscopic information for the best spectrum of that object. The keywords for each row are a subset of the FITS parameters for the primary image (the parameters in Table 1 with an '=' between Keyword and Value; those with an 'x' instead of an '=' are *not* in the mSQL database) plus all the additional keywords listed in Table 3. The best spectrum is the one with the highest redshift quality parameter; if there is more than one spectrum of the same quality, then the latest of these spectra is taken to be the best.

Subsequent rows for the same object (`extnum=1..spectra`, where `spectra` is the number of spectra obtained for that object) contain a subset of the FITS parameters pertaining to each spectroscopic observation (the parameters in Table 2 with an '=' between Keyword and Value; those with an 'x' instead of an '=' are *not* in the mSQL database) plus the additional keywords in section (i) of Table 3. If there is no spectrum for the object then `spectra=0` and only the row corresponding to `extnum=0` will exist. Note that some information is duplicated between rows and that not all parameters are defined for all rows; undefined parameters return a `NULL` value.

The best spectrum is indicated by the parameter `best`, which is present in all extensions: in the primary extension (`extnum=0`) its value is the number of the extension with the best spectrum; in the spectral extensions (`extnum>0`) its value is 1 if that extension contains the best spectrum and 0 otherwise.

Table 3: Additional mSQL database keywords

(i) Keywords in all extensions

Keyword	= Value	/ Description
<code>serial</code>	= 100100	/ 2dFGRS serial number
<code>name</code>	= TGS469Z164	/ 2dFGRS name
<code>UKST</code>	= 417	/ UKST sky survey field number
<code>spectra</code>	= 1	/ number of spectra for this object
<code>extnum</code>	= 1	/ extension number
<code>best</code>	= 1	/ in extension 0, extension number with best spectrum / in extension>0, 1 if best spectrum and 0 otherwise
<code>obsrun</code>	= 99OCT	/ observing run year and month
<code>TDFgg</code>	= -469	/ 2dFGRS field number (+NGP,-SGP)
<code>pivot</code>	= 302	/ 2dF pivot
<code>plate</code>	= 1	/ 2dF plate
<code>fiber</code>	= 58	/ 2dF fiber
<code>z</code>	= 0.178876	/ observed redshift
<code>z_helio</code>	= 0.178860	/ heliocentric redshift
<code>abemma</code>	= 1	/ redshift type (abs=1,emi=2,man=3)
<code>quality</code>	= 5	/ redshift quality parameter

(ii) Keywords in extension 0 only

Keyword	= Value	/ Description
<code>alpha</code>	= 0.7943429758	/ RA (B1950) in radians
<code>delta</code>	= -0.5475286941	/ DEC (B1950) in radians
<code>ra</code>	= 3 2 3.00	/ RA (B1950) in HH MM SS.SS
<code>dec</code>	= -31 22 15.9	/ DEC (B1950) in DD MM SS.S
<code>ra2000</code>	= 03 04 07.68	/ RA (J2000) in HH MM SS.SS
<code>dec2000</code>	= -31 10 36.8	/ DEC (J2000) in DD MM SS.S
<code>l2</code>	= 228.9258834424	/ Galactic longitude
<code>b2</code>	= -60.8572447739	/ Galactic latitude

Searches of the database use the mSQL query format (Jepson & Hughes, 1998), which has the general format

```
SELECT list_of_parameters FROM database_name WHERE list_of_conditions
```

(here `list_of_conditions` is a series of equalities and inequalities linked by Boolean relations).

An example is

```
SELECT name, extnum, ra, dec, BJSEL, Z, QUALITY, z, quality FROM TDFgg
WHERE name='TGS469Z164'
```

which selects the listed parameters for the object with 2dFGRS name TGS469Z164 (note the single quotes around the character string) from both the summary row (`extnum=0`) and for each spectrum (`extnum=1..spectra`). Note that the parameters with the same name in lower case and upper case are distinct: the former are generally from `extnum=0`, the latter from `extnum>0` (parameters are returned as `NULL` in rows where they are not defined).

Another example with a more complex list of conditions is

```
SELECT name FROM TDFgg
WHERE extnum=0 AND ((BJSEL<15.5 AND quality>=3) OR quality>4)
```

which lists just the names of the objects which are either brighter than  $b_j=15.5$  with redshift quality at least 3, or have quality greater than 4, or both; the search is restricted just to the summary row by requiring `extnum=0`

One common and useful type of search is where parameters from only the best spectrum (or from the best spectrum and the primary extension) are desired. This can easily be achieved using the `best` parameter. For example,

```
SELECT serial,name,extnum,ra2000,dec2000,z_helio,ETA_TYPE FROM TDFgg
WHERE best>0 AND quality>=3 ORDER BY serial,extnum
```

extracts a list of positions, redshifts and spectral types for all objects with reliable ( $Q \geq 3$ ) redshifts, using only the best spectrum for each object. Both the primary extension and the best spectrum extension are needed because some of the desired parameters are only in one or other. As a result the list has two rows for each object, and so to make subsequent processing easier the `ORDER BY` construction is used to sort on serial number and extension (so that the list is ordered by serial number and then extension, with the primary first and the best spectrum second). Note, however, that `ORDER BY` is very slow for large datasets, and it is much better to sort off-line. Variants on this type of search using parameters only in the primary extension or the best spectrum extension can be obtained by suitable conditions on `extnum` and `best`.

Simple searches on the two indexed parameters (`serial` and `name`), are quick - e.g. `WHERE serial=69656` or `WHERE name='TGS203Z081'`; more complex searches take about 5 minutes. Use of the `ORDER BY` construction is very slow for large datasets, and is not generally recommended.

Further information about the mSQL database software and its structured query language is given in Yarger et al. (1999) and on the WWW.

### 3.3 WWW Interface

The 2dFGRS mSQL database can be searched via the WWW interface in a number of ways:

1. perform a standard mSQL query as described above - this is the most general method;
2. perform a standard mSQL query restricted to a list of named objects - this allows searching on any defined subsample;
3. perform a standard mSQL query restricted to objects within a specified radius of a given sky position;
4. match objects to a supplied catalogue of positions.

The results of a query can be returned either directly as an HTML table (suitable for relatively small datasets) or via an email giving the URL of the results file (suitable for large datasets). The results file may be either a compressed text (gzipped ASCII) file containing the chosen *parameters* for the objects selected by the mSQL query, or a compressed archive (gzipped tarfile) of the *FITS files* for the objects selected by the query, depending upon the option selected. If results are returned as an HTML table, then objects can be selected interactively and their DSS images (and for the on-line database, their SuperCosmos images) and their spectra can be displayed. If the spectra have measured redshifts, then the plot of each spectrum shows the positions of prominent spectral features at the redshift associated with that spectrum.

## 4 PHOTOMETRIC CALIBRATION

### 4.1 SuperCosmos data

The 2dFGRS final release differs from the 100k preliminary release in that the  $b_j$  photometry has been recalibrated. Also, red photometry from the UKST  $r_F$  plates is now available.

The original 2dFGRS magnitudes were based on APM scans of the UKST  $b_j$  plates, but the APM never completed scans of the  $r_F$  plates. This has now been completed by the SuperCosmos measuring machine. This has some advantages in precision with respect to the APM, so a first step was to calibrate the SuperCosmos  $b_j$  and  $r_F$  data, followed by recalibration of the 2dFGRS APM magnitudes by comparison with SuperCosmos. See Hambly et al. (2001, MNRAS, 326, 1279) for details of the basic SuperCosmos catalogue, and also <http://www-wfau.roe.ac.uk/sss/>.

The SuperCosmos recalibration is APM-like in that it matches overlaps. Each plate is given a 2-coefficient transformation:

$$\text{SuperCosmos mag} = a * \text{true mag} + b$$

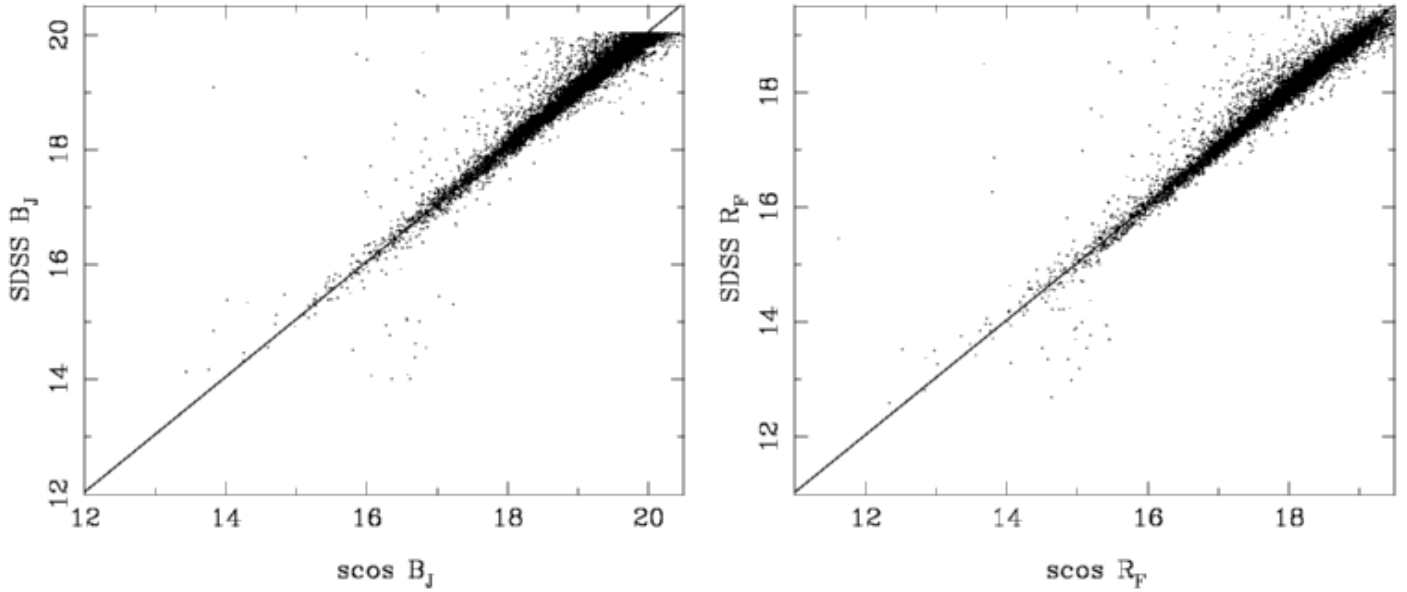
each plate is also allowed to have a different degree of differential de-sensitization with radius. Such systematics can differ from plate to plate, and the differences can be accurately measured from the overlap data. The typical effect is 0.02 mag at 2.5 degrees radius, and 0.08 mag at the corner of the 5x5 degree region - but these numbers can change by factors of 2 or more from plate to plate. The 3 free parameters per plate are allowed to float in order to optimise the agreement of the overlaps. Plates at low latitude, where the stellar contamination is high, are excluded.

The magnitudes are placed on an absolute scale using SDSS in 33 plates and EIS in 8. Both these datasets cover both Galactic hemispheres. The SuperCosmos data seem to be very good and homogeneous:

- The magnitudes are "quasi-linear": SuperCosmos mag = a \* SDSS + b works without the need for quadratic terms.
- the random error is small: a sigma-clipped rms in  $b_j$  SuperCosmos-SDSS of only 0.09 mag on a single plate. The corresponding figure for 2dFGRS is about 0.15 mag. The error in  $r_F$  is 0.10 mag.

F

The agreement with SDSS data and quasi-linear calibrated SuperCosmos data is shown below.



In addition, the calibration at bright magnitudes is constrained so that the median extinction-corrected optical-2MASS J colours are uniform within the errors. This is done separately for  $b_J$  and  $r_F$ . A small final perturbation to the calibration is performed so that the median extinction corrected  $b_J$ - $r_F$  colours are uniform within the errors. The final dispersion in median  $b_J$ - $r_F$  values from plate to plate is about 0.02 mag. Since the 2MASS zero points are estimated to be good to 0.03 mag rms over the whole sky, the SuperCosmos optical data should now be calibrated to the same accuracy.

## 4.2 UKST colour terms

In making the absolute calibration, the SDSS EDR data were placed on a true AB95 scale by applying the offsets from Blanton et al. (astro-ph/0210215). The colour corrections from Fukugita et al. (1995, PASP, 107, 945) were then assumed, to relate SDSS photometry to Johnson-Cousins:

$$\begin{aligned} B &= g + 0.217 + 0.419(g-r) \\ V &= g - 0.002 - 0.533(g-r) \\ R &= r - 0.155 - 0.089(g-r) \end{aligned}$$

The UKST colour equations were then determined to be

$$\begin{aligned} b_J &= B - 0.304(B-V) \\ r_F &= R + 0.163(V-R) \end{aligned}$$

forcing the UKST photometry to share the Johnson-Cousins zero point. In direct SDSS units, this is

$$\begin{aligned} b_J &= g + 0.150 + 0.130(g-r) \\ r_F &= r - 0.130 \end{aligned}$$

## 4.3 SuperCosmos recalibration of 2dFGRS

When the SuperCosmos  $b_J$  data are compared to the 2dFGRS APM photometry, there is evidence for a small nonlinear term, which can be eliminated by applying a correction

$$b_J' = b_J + 0.033((b_J - 18)^2 - 1) \quad b_J > 15.5 \quad (\text{fixed } b_J' - b_J \text{ for } < 15.5)$$

One can now fit quasilinear corrections to the APM photometry to optimise the agreement with SuperCosmos:

$$b_J'' = A b_J' + B$$

The coefficients A and B are determined for each plate. The numbers  $b_J''$  are the final 2dFGRS magnitudes given in the release database, although the original photometry and the 100k recalibration are included for completeness, as well as the SuperCosmos magnitudes. If colours are desired, the SuperCosmos photometry is to be preferred, as the accuracy of 0.09 mag rms per band is superior to the 0.15 random error from the APM photometry. Nevertheless, since the selection was made in terms of the APM magnitudes, these must be retained for some purposes.

## 4.4 Matching APM and SuperCosmos sources

Finally, some explanation is in order of how the appropriate images in the SuperCosmos and APM data were matched. This is not trivial, since

SuperCosmos has the ability to deblend images. This is desirable in the case of galaxy pairs, but bright galaxies can tend to be broken up artificially. In the end, a pragmatic approach was taken which aims to pick out the cases where there is an issue over how much deblending is desirable.

## $b_J$ matching

Six classes were defined for matching APM sources with SuperCosmos, having adjusted the APM photometry to best match SuperCosmos.

- B Class 1: Deblended or isolated images within 2" and 0.2 mag.
- B Class 2: A blend within 2" and 0.2 mag (but only if no class 1 candidate). Especially for bright galaxies, SuperCosmos blends match what the APM did much better - and it is sensible not to split up such cases.
- B Class 3: Only one candidate object within 8" (irrespective of whether it's a blend), which matches to 3" and 0.3 mag.
- B Class 4: Choose the best object via  $\min \chi^2 < 2$ , where  $\chi^2 = (\Delta \text{rad}/2")^2 + (\Delta m/0.2)^2$ . Consider blends and non-blends.
- B Class 5: As for class 4, but  $\min \chi^2 > 2$ .
- B Class 6: Objects with no ID - objects where there is "no" counterpart within 8 arcsec. The definition of "no" depends on depth: a cutoff was imposed at galaxy-corrected SuperCosmos  $B=20.5$ ; fainter than this, the APM source is effectively not real.

Statistics for the  $b_J$  matching:

```
B Class 1 = 88.6%
B Class 2 = 6.3%
B Class 3 = 2.3%
B Class 4 = 0.6%
B Class 5 = 1.7%  Total IDs    = 99.4%
B Class 6 = 0.6%  Total no IDs = 0.6%
```

The objects without ID were included with the sources rejected on the basis of visual examination.

## $r_F$ matching

Now we have to find  $r_F$  counterparts for the objects in  $b_J$  classes 1-5. The matching was done with the SuperCosmos positions, rather than the APM position, which allows a tighter tolerance. It seemed sensible to consider blends and non-blends separately, since matching a blended  $b_J$  source to a deblended  $r_F$  component could generate incorrect colours.

Again, a number of classes are defined:

- R Class 1: Take B classes 1-4, where we probably have the right object, and accept a counterpart with the same blend flag within 1".
- R Class 2: As for R class 1, but with B class 5 objects. Many of the latter are dubious, but a good R match probably verifies them.
- R Class 3: For any B class, accept the closest object within 2", provided blend flags match.
- R Class 4: As for R class 3, but accept matches with different blend flags.
- R Class 5: Closest with separation  $> 2"$  and blend flags match.
- R Class 6: Closest with separation  $> 2"$  and different blend flags.
- R Class 7: No R object within 30" to the plate limit. There are few of these, and most are probably junk.

Statistics for the  $r_F$  matching:

```
R Class 1 = 81.2%
R Class 2 = 0.6%
R Class 3 = 4.9%
R Class 4 = 9.1%
R Class 5 = 2.5%
R Class 6 = 1.6%
R Class 7 = 0.0%
```

# 5 PHOTOMETRIC CATALOGUES

These ASCII text catalogues are provided for the convenience of users of the 2dFGRS Final Data Release. However it is important to note that the MySQL database is the definitive data source, and contains all the information in the ASCII text catalogues and much additional data.

## 5.1 Input photometric catalogues (source catalogues)

The photometric catalogues (ngp.cat, sgp.cat and ran.cat for the NGP, SGP and random fields) have been derived from APM scans of the Southern Sky Survey (see Colless et al. 2001). The catalogues are highly complete down to their nominal limit at an extinction-corrected magnitude ( $B_{JSEL}$ ) of approximately  $b_J=19.45$ ; this limit varies slightly from field to field, as described in detail by the [survey masks](#).

All sources in the photometric catalogues have a unique serial number (`serial=SEQNUM`), running from 1 to 389713, which is the primary database key. There are 382323 sources in these catalogues; the 7390 missing serial numbers correspond to sources rejected as artifacts on the basis of visual examination of their images, as detailed in the [description](#) of the 2dFGRS database.

Each line of these catalogues contains the following parameters:

Keyword	Format	Description
SEQNUM	I6	Assigned sequence number to this object; determines the FITS filename (SEQNUM.fits)
ra	A11	R.A. (B1950) in HH MM SS.SS

dec	A11	Dec. (B1950) in DD MM SS.S
BJSEL	F6.3	Final bj magnitude with extinction correction (i.e. with corrections for isophote, field-effects and plate-matching, then calibrated to total mags with saturation correction, and then extinction corrected)
PROB	F6.1	psi classification parameter: for eyeballed galaxies psi*1000 = (10000 + abs(jon) + psi*100) for eyeballed non-galaxies psi*1000 = -(10000 + abs(jon) + psi*100)
PARK	F5.3	k classification parameter = k / k_star
PARMU	F5.3	mu classification parameter = mu / mu_star
IGAL	I2	Final classification -4 = noise -3 = star + star -2 = star + fuzz -1 = star 0 = galaxy + star merger 1 = galaxy 2 = galaxy + galaxy merger
JON	I2	Eyeball classification, value > 0 only for galaxies brighter than about 18th mag: 0 = noise 1 = S0 2 = elliptical 3 = spiral 4 = irregular 5 = undetermined galaxy 6 = star 7 = star + star merger 8 = galaxy + star merger 9 = galaxy + galaxy merger
ORIENT	F5.1	Orientation measured in degrees clockwise from E to W: orient = 180/pi * atan(2*sxy/((sxx + syy)*(1 + e)-syy))
ECCENT	F5.3	Eccentricity (e) e*200 = 200*((sxx-syy)**2 + 4sxy**2)**0.5/(sxx + syy)
AREA	F6.0	Isophotal area in pixels
X_BJ	F8.1	Plate x_bj in 8 micron pixels
Y_BJ	F8.1	Plate y_bj in 8 micron pixels
DX	F5.0	Distortion corrected difference (x_bj - x_R)*100
DY	F5.0	Distortion corrected difference (y_bj - y_R)*100
BJG	F6.3	Final bj magnitude without extinction correction
RMAG	F5.2	Unmatched APM 'total' mag
PMAG	F5.2	Unmatched raw APM profile integrated mag
FMAG	F5.2	Unmatched raw APM 2" profile integrated mag
SMAG	F5.2	Unmatched raw stellar mag (from APMCAL)
REDMAG	F5.2	Not used
IFIELD	I3	UKST field
IGFIELD	I6	Galaxy number in UKST field
NAME	A10	2dFGRS assigned name; if either (i) BJSELOLD is fainter than 19.45, or (ii) the object could not be allocated to a fibre by the configuration algorithm, then NAME is blank
BJG_OLD	F5.2	Original bj magnitude without extinction correction (prior to re-calibration to BJG)
BJSELOLD	F5.2	Original bj magnitude with extinction correction (prior to re-calibration to BJSEL); used to select survey sample
100_BJG	F5.2	100k release bj magnitude without extinction correction (prior to re-calibration to BJG)
100BJSEL	F5.2	100k release bj magnitude with extinction correction (prior to re-calibration to BJSEL)

Note that there are three pairs of APM  $b_j$  magnitudes in each file, the pairs being with and without the extinction correction. Each of these three pairs correspond to progressive refinements of the photometric calibrations. The original calibration used to select the 2dFGRS sample corresponds to BJG\_OLD and BJSELOLD; the calibration used for the 100k release corresponds to 100\_BJG and 100BJSEL; the final, and best, calibration corresponds to BJG and BJSEL. The latter are the magnitudes that should in general be used; the original magnitudes are useful in understanding the original selection of the sample; the 100k magnitudes are useful for comparing analyses based on the two data releases.

## 5.2 Deleted source lists

The objects deleted from the final source catalogues on the basis of visual inspection during a first pass at the time the catalogues were constructed are listed in deleted\_pass1.cat. The objects deleted from the final source catalogues on the basis of visual inspection during a second pass based on a comparison of the APM and SuperCosmos source parameters are listed in deleted\_pass2.cat. These files have the same format as the source catalogues. Details of the procedure are given in the [description](#) of the database. The objects in these lists are *not* in the final source catalogues.

### 5.3 Tile centres

The centres of all the 2dFGRS tiles are listed in centres.ngp, centres.sgp and centres.ran. These files list R.A. and Dec. (B1950, in decimal degrees), tile number, tile name, and R.A. and Dec. (B1950, in HH MM SS.SS-DD MM SS.S).

## 6 SPECTROSCOPIC CATALOGUES

These ASCII catalogues are provided for the convenience of users of the 2dFGRS Final Data Release. However it is important to note that the mSQL database is the definitive data source, and contains all the information in the ASCII catalogues and much additional data.

### 6.1 best.observations.idz

This file contains data for the best spectrum for each of the 245591 sources in the final data release. Where there is more than one 2dFGRS spectrum for a source, the best spectrum is the one with the highest redshift quality code; if there is more than one spectrum of this quality, then the spectrum with the latest date of observation is used. Each line of best.observations.idz contains the following parameters:

Keyword	Format	Description
serial	I6	Database serial number (=SEQNUM)
spectra	I1	Number of spectra obtained
name	A10	2dFGRS name (=NAME)
UKST	A3	UKST plate (=IFIELD)
ra	A11	R.A. (B1950)
dec	A11	Dec. (B1950)
ra2000	A11	R.A. (J2000)
dec2000	A11	Dec. (J2000)
BJG	F6.3	Final bj magnitude without extinction correction
BJSEL	F6.3	Final bj magnitude with extinction correction
BJG_OLD	F6.3	Original bj magnitude without extinction correction
BJSELOLD	F6.3	Original bj magnitude with extinction correction
GALEXT	F5.3	Galactic extinction value
SB_BJ	F6.3	SuperCosmos bj magnitude without extinction correction
SR_R	F6.3	SuperCosmos R magnitude without extinction correction
z	F9.6	Best redshift (observed)
z_helio	F9.6	Best redshift (heliocentric)
obsrun	A5	Observation run of best spectrum
quality	I1	Redshift quality parameter for best spectrum (quality=1-5; reliable redshifts have quality>=3)
abemma	I1	Redshift type (abs=1, emi=2, man=3)
Z_ABS	F9.6	Cross-correlation redshift from best spectrum
KBESTR	I1	Cross-correlation template from best spectrum
R_CRCOR	F5.3	Cross-correlation R value from best spectrum
Z_EMI	F9.6	Emission redshift from best spectrum
NMBEST	I2	Number of emission lines for Z_EMI from best spectrum
SNR	F6.2	Median S/N per pixel from best spectrum
ETA_TYPE	F10.6	Eta spectral type parameter from best spectrum (-99.9 if none)

### 6.2 all.observations.idz

This file contains data for all observations of the 245591 sources in the final data release; all.observations.idz contains 515528 lines with each source having at least two lines in the file, with formats as follows:

Keyword	Format	Description
Line 1 for each source lists...		
serial	I6	Database serial number (=SEQNUM)
spectra	I1	Number of spectra
name	A10	2dFGRS name (=NAME)
UKST	A3	UKST plate (=IFIELD)
ra	A11	R.A. (B1950)
dec	A11	Dec. (B1950)
ra2000	A11	R.A. (J2000)
dec2000	A11	Dec. (J2000)
BJG	F6.3	Final bj magnitude without extinction correction
BJSEL	F6.3	Final bj magnitude with extinction correction
BJG_OLD	F6.3	Original bj magnitude without extinction correction
BJSELOLD	F6.3	Original bj magnitude with extinction correction
GALEXT	F5.3	Galactic extinction value
SB_BJ	F6.3	SuperCosmos bj magnitude without extinction correction
SR_R	F6.3	SuperCosmos R magnitude without extinction correction
best	I1	FITS extension number of the best spectrum
z	F9.6	Best redshift (observed)
z_helio	F9.6	Best redshift (heliocentric)
quality	I1	Redshift quality parameter (quality=1-5; reliable redshifts have quality>=3)
obsrun	A5	Observation run of best spectrum
Lines 2..spectra+1 list details of each spectrum...		
serial	I6	Database serial number (=SEQNUM)
name	A10	2dFGRS name (=NAME)
UTDATE	A10	UT date of observation
OBSRUN	A5	Observation run
Z	F9.6	Redshift (observed)
Z_HELIO	F9.6	Redshift (heliocentric)
QUALITY	I1	Redshift quality parameter
ABEMMA	I1	Redshift type (abs=1, emi=2, man=3)

Z_ABS	F9.6	Cross-correlation redshift
KBESTR	I1	Cross-correlation template
R_CRCOR	F5.3	Cross-correlation R value
Z_EMI	F9.6	Emission redshift
NMBEST	I2	Number of emission lines for Z_EMI
SNR	F6.2	Median S/N per pixel
ETA_TYPE	F10.6	Eta spectral type parameter (-99.9 if none)

### 6.3 Parent.reg.txt

These files (reg=ngp/sgp/ran/2dF) contain details of all observations of sources in each of the NGP, SGP and RAN regions.

- parent.ngp.txt: contains 145652 entries for NGP strip sources.
- parent.sgp.txt: contains 204490 entries for SGP strip sources.
- parent.ran.txt: contains 57698 entries for random field sources.
- parent.2dF.txt: contains 407840 entries for sources in all survey regions.

The format for these files is as follows:

Keyword	Format	Description
serial	I6	Database serial number (=SEQNUM)
alpha	F16.13	R.A. (B1950) in radians (=RA)
delta	F16.13	Dec. (B1950) in radians (=DEC)
BJSEL	F5.2	Final bj magnitude with extinction correction
Z	F7.5	Redshift (observed); -9.99 if no spectrum
Z_HELIO	F7.5	Redshift (heliocentric); -9.99 if no spectrum
bjlim	F6.3	2dFGRS bj magnitude limit of this area; -1.000 for sources not included in the survey sample
QUALITY	I1	Redshift quality parameter (quality=1-5; reliable redshifts have quality>=3)
BJG	F5.2	Final bj magnitude without extinction correction
BJSELOLD	F5.2	Original bj magnitude with extinction correction
BJG_OLD	F5.2	Original bj magnitude without extinction correction
UKST	A3	UKST plate (=IFIELD)
obsfld	I3	Observed field number (=OBSFLD(4:6)); -99 if none
GRSDATE	A6	Observation date; -99 if none
ETA_TYPE	F8.3	Eta spectral type parameter; -99.9 if not determined
PLATE	I3	2dF plate number (0 or 1); -99 if none
ECCENT	F5.3	Eccentricity
ORIENT	F5.1	Orientation
JON	I2	Eyeball classification
AREA	F6.0	Isophotal area in pixels

## 7 SURVEY MASKS

For accurate statistical analysis of the 2dFGRS it is essential to fully understand the criteria that define the parent photometric catalogue and also the completeness of the redshift catalogue, as discussed in Colless et al. (2001) and Norberg et al. (2002). For this purpose we have defined maps or masks characterizing this information as a function of position on the sky:

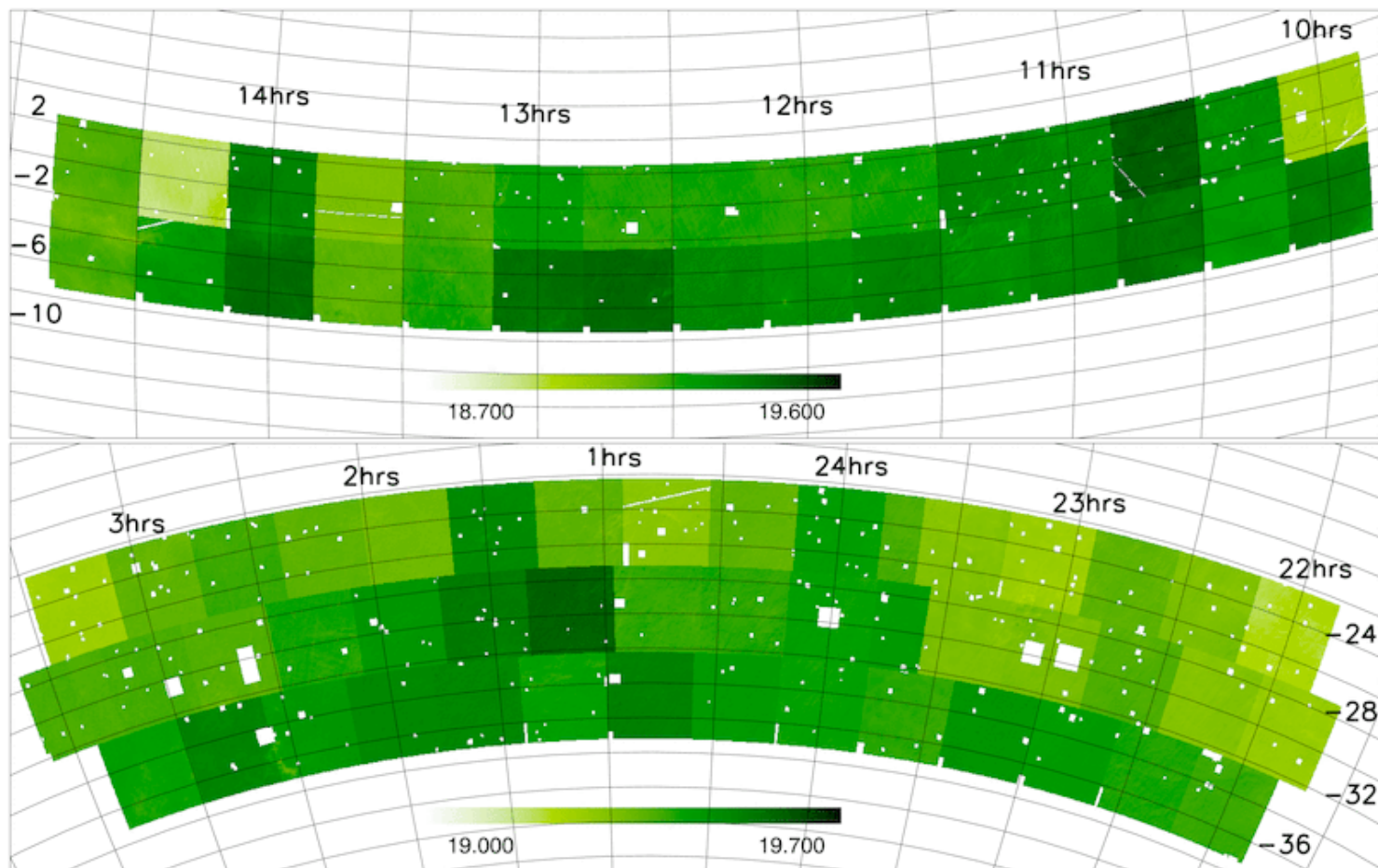
1. The magnitude limit mask gives the extinction-corrected magnitude limit of the survey at each position.
2. The redshift completeness mask gives the fraction of measured redshifts at each position.
3. The mu-mask gives the dependence of the redshift completeness on apparent magnitude.

We now describe in more detail how these masks are defined and briefly outline some of their uses.

### 7.1 Magnitude limit mask

Although the 2dFGRS sample was originally selected to have a uniform extinction-corrected magnitude limit of  $b_j=19.45$ , in fact the survey magnitude limit varies slightly with position on the sky. There are two reasons for this. First, the photometric calibrations now available are much more extensive than when the parent 2dFGRS catalogue was originally defined. This has enabled us to recalibrate the whole 2dFGRS parent catalogue and results in improved zero-point offsets and linearity corrections for each of the UKST photographic plates. Second, the extinction corrections have been changed to use the final published version of the Schlegel et al. (1998) extinction maps; the original extinction corrections came from a preliminary version of those maps.

The magnitude limit mask is therefore defined by the change in the photometric calibration of each UKST photographic plate and the change in the dust extinction correction at each position on the sky. The magnitude limit masks for the NGP and SGP strips using the photometric calibration of the 2dFGRS Final Data Release are shown below in a zenithal equal area projection. Note that the masks also account for the holes in the source catalogue around bright stars and plate flaws.



In the SGP, which is a subset of the APM galaxy survey (Maddox et al. 1990a,b), the rms change in plate zero-point is only 0.03 mag. However, in the NGP region the original calibration was less accurate and the change in zero-points have an rms of 0.08 mag. The change in the dust corrections are also less in the SGP, as the extinction is generally lower in this region. In the SGP the rms magnitude change due to improved dust corrections is 0.01 mag while in the NGP it is 0.02 mag.

In the SGP the mean limiting magnitude is  $b=19.40$  with an rms about this value of 0.08 mag; in the NGP the mean limiting magnitude is  $b=19.29$  with an rms of 0.12 mag.

For accurate statistical analysis of the 2dF survey, the magnitude limits defined by this mask should be used. It is always possible to analyse the data with a fixed magnitude limit if one is prepared to omit both the areas of the survey that have magnitude limits brighter than the chosen limit and also all the galaxies in the remaining areas with magnitudes fainter than the chosen limit.

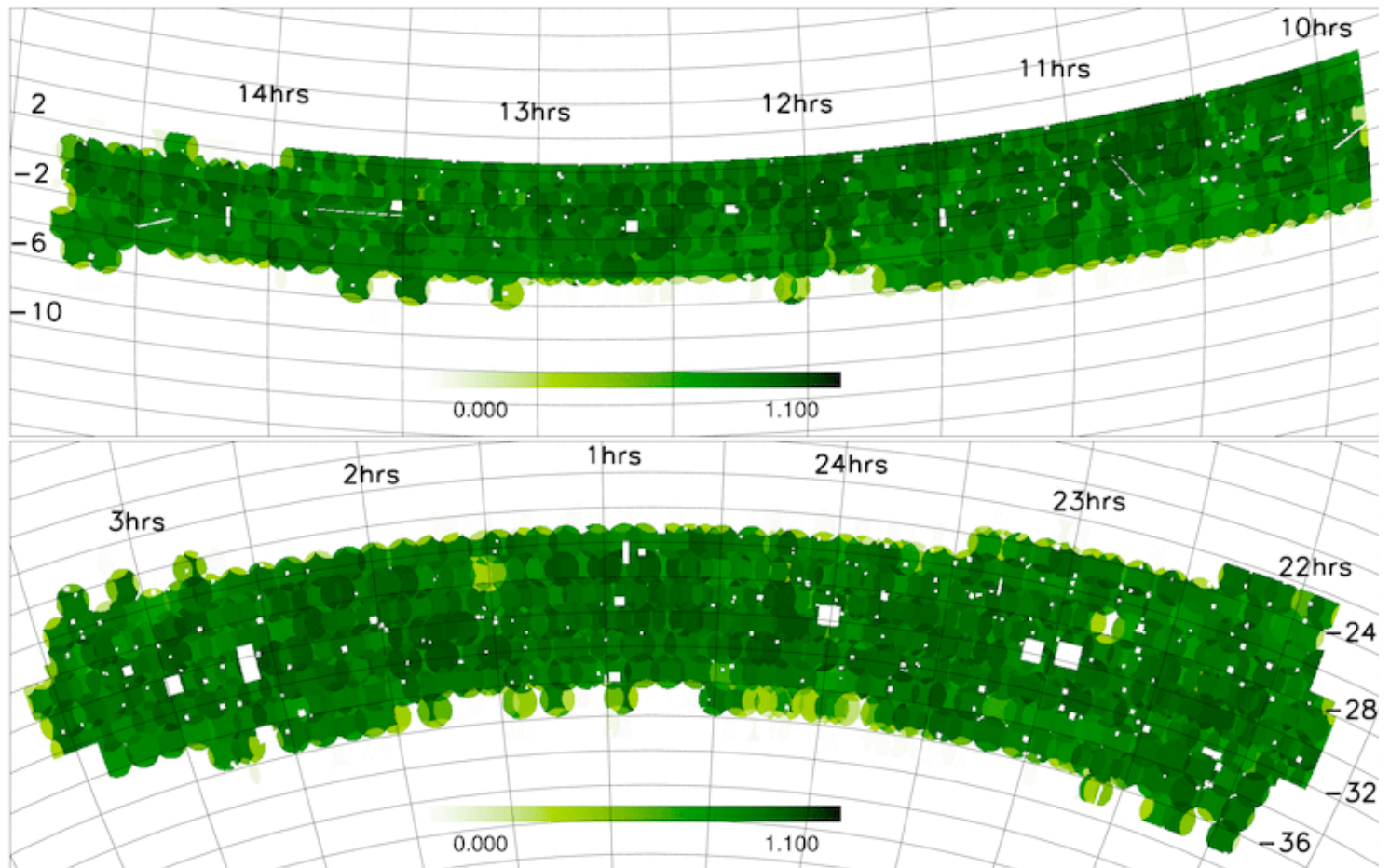
## 7.2 Simple redshift completeness mask

The best way to define a redshift completeness mask is to make use of the geometry defined by the complete set of 2 degree fields that were used to tile the survey region for spectroscopic observations. Each region of the sky inside the survey boundary is covered by at least one 2 degree field, but more often by several overlapping fields. We define a sector as the region delimited by a unique set of overlapping 2 degree fields. This is the most natural way of partitioning the sky, as it takes account of the geometry imposed by the pattern of 2 degree fields and the way in which the galaxies were targeted for spectroscopic observation. Within each sector,  $\theta$ , we define the redshift completeness,  $R(\theta)$ , as the ratio of the number of galaxies for which redshifts have been obtained,  $N_z(\theta)$ , to the total number of objects contained in the parent catalogue,  $N_p(\theta)$ :

$$R(\theta) = N_z(\theta)/N_p(\theta) .$$

The redshift completeness of a given sector,  $R(\theta)$ , should be clearly distinguished from the redshift completeness of a given field,  $C_F$ , since multiple overlapping fields can contribute to a single sector.

The redshift completeness masks for the 2dFGRS Final Data Release (where redshift completeness is defined as above) are shown below. The masks are plotted in a zenithal equal area projection.



These simple redshift completeness masks can be used to locate regions in which the redshift completeness is high. They can also be used as a first step in either applying weights to statistically correct for incompleteness or to construct random unclustered catalogues that have the same angular pattern of incompleteness as the redshift sample (for use in estimating correlation functions).

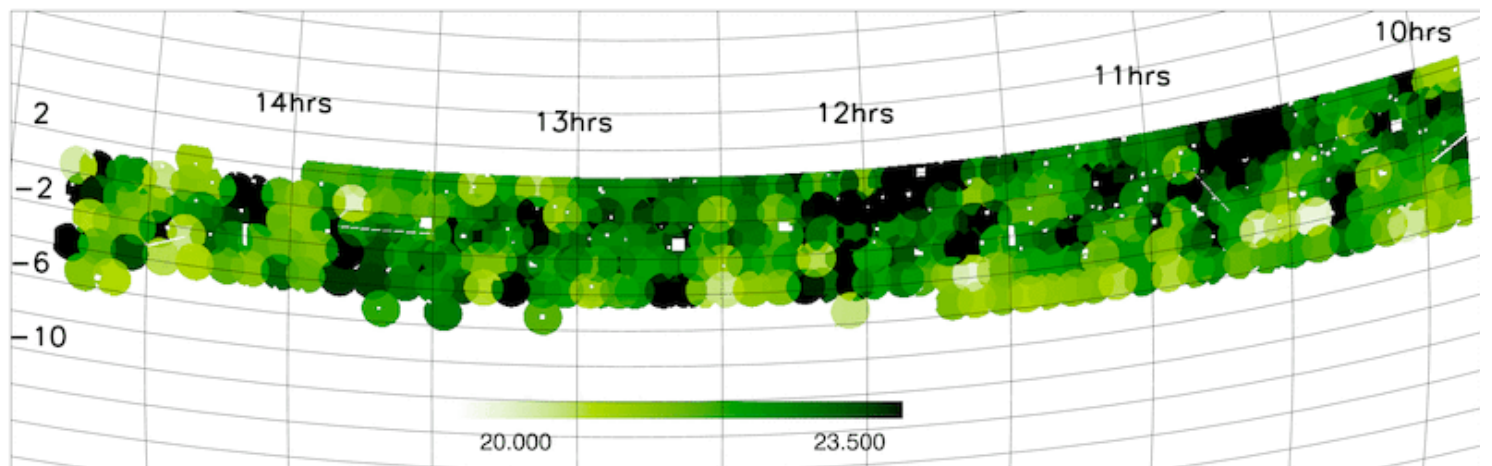
For this latter purpose, one should also take account of how the redshift completeness depends on position within a sector as a result of constraints on fibre positioning and other considerations. This is best done by using the parent catalogue to derive weights for each galaxy with a measured redshift (see Norberg et al. 2002).

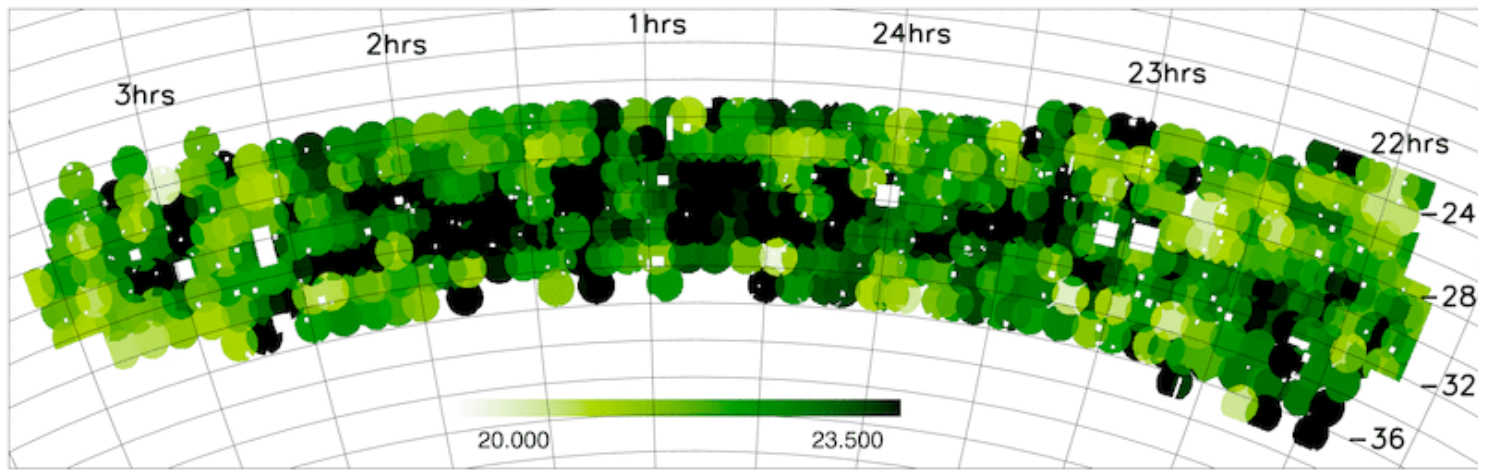
### 7.3 Magnitude-dependent completeness corrections (mu-mask)

For many applications one also needs to take account of how the redshift completeness depends on apparent magnitude, as discussed in detail in Colless et al. (2001) and Norberg et al. (2002). This requires knowing the  $\mu$  parameter that characterises the fall-off in completeness with apparent magnitude for each sector.

*Note:* In the definition of the magnitude-dependent completeness mask in section 8.3 of Colless et al. (2001), there is an error in the value given for the parameter  $\alpha$ ; the paper gives  $\alpha=0.5$ , but the correct value is  $\alpha=0.5\ln(10)$ .

The  $\mu$ -masks for the 2dFGRS Final Data Release are shown below. The masks are plotted in a zenithal equal area projection.





## 8 MASK SOFTWARE

### 8.1 Copyright and use of the mask codes

As a user of the mask codes, we request that you observe the following guidelines:

- The code provided here has been written by several members of the 2dFGRS team. Peder Norberg and Shaun Cole (University of Durham, UK) wrote the software used to create the survey masks. If you use any part of this 2dFGRS software, please acknowledge "the 2dFGRS mask software by Peder Norberg and Shaun Cole".
- This code is supplied as-is and without guarantees - use it with caution and report any bugs.
- Read all of the documentation before trying to use the code!

### 8.2 The mask data files

Copy the following files:

- mask.ngp.dat (completeness mask for the NGP strip)
- mask.sgp.dat (completeness mask for the SGP strip)
- mask.ran.dat (completeness mask for the random fields)
- maglim.ngp.dat (magnitude limit mask for the NGP strip)
- maglim.sgp.dat (magnitude limit mask for the SGP strip)
- maglim.ran.dat (magnitude limit mask for the random fields)
- mumask.ngp.dat (mu-mask for the NGP strip)
- mumask.sgp.dat (mu-mask for the SGP strip)
- mumask.ran.dat (mu-mask for the random fields)

### 8.3 Example code for using the masks

- Copy the following files:
  - `makefile` (for compilation)
  - `release.f` (the program code)
- Choose the right compiler for your machine by selecting/deselecting the appropriate lines in the `makefile`. This code has been tested on Sun Solaris, DEC Alpha and PC Linux (with the Intel ifc compiler).
- Given R.A. and Dec. (B1950, in radians), `release` returns the completeness, the magnitude limit, the mu value and the UK Schmidt Telescope (UKST) sky survey plate number at that particular position. When `compl = -1`, the given position is outside the main 2dF boundary; when `compl = -2`, the given position is inside an excluded region (a 'hole').

### 8.4 Generating selected samples and mock catalogues

- *Introduction:* As well as the example code above, we also provide code for selecting subsets of the survey data (using various criteria defined by the user - see below) and generating an associated unclustered catalogue of with the same set of selection criteria. By changing various flags one can create volume- or magnitude-limited catalogues, select galaxies within a given range in absolute or apparent magnitude, choose only those with a given spectral class or simply select galaxies within a given redshift range or within regions of given completeness. The main purpose of this code is the generation of the associated distribution of unclustered galaxies with the same selection criteria (a mock catalogue).
- *Installing the code:* Create a directory to work in and copy to it `release_230k.tar.gz` (468Mb uncompressed, 50Mb compressed) and `aux_data.tar.gz` (168Mb uncompressed, 120Mb compressed). Gunzip and untar these files. This will produce the following directories:

```
release_230k/
release_230k_sgp/
release_230k_ngp/
release_230k_ran/
aux_data/
```

If you do not have Starlink libraries on your system, also copy to the working directory `fitsio.tar.gz` (1.5Mb uncompressed, 0.2Mb compressed) and `sla.tar.gz` (0.9Mb uncompressed, 0.2Mb compressed). The source code for these routines comes from the Starlink website, but has been slightly modified so as to also work with the Intel `ifc` compiler under Linux. Gunzip and untar these to produce the following directories:

```
fitsio/
sla/
```

Finally, copy to the working directory `select_release.tar.gz` (0.8Mb uncompressed, 0.2Mb compressed). Gunzip and untar this to produce:

```
readme_release.txt
makefile
select_release.com
main/selection_release.f      # sample selection and mock catalogue code
sub/dist.for                  # subroutines used by the main codes
sub/holes.f
sub/in_2df_mask_select.f
sub/indx.f
sub/iounix.f
sub/locate.f
sub/mag_error.f
sub/pix_ran.inc
sub/ran3.f
sub/ran_all.f
sub/ranmask.f
sub/readasci.f
sub/rtsafe.f
sub/selfunc.f
sub/tabulate_selfile.f
sub/allheaders.dat           # additional data files
sub/distortion
sub/ngpholes.lis
sub/sgpholes.lis
sub/rancentres.txt          # data files for the random fields
sub/ranfield_area.dat
seldir/selfile.230k.2df_sgp  # selection function files
seldir/selfile.230k.2df_ngp
seldir/selfile.230k.2df_ran
seldir/selfile.230k.txt
outdir/                      # directory for output
```

Choose the right compiler for your machine by selecting/deselecting the appropriate lines in the `makefile`. This code has been tested on Sun, Alpha Dec and Linux (with the Intel `ifc` compiler).

- **Running the code:** The script `select_release.com` compiles the executable `select_release` and runs it for the parameters contained in the script. These parameters, which can be changed by the user, are described (with typical values) below:

```
# Switches with F (false) and T (true) options
set dirp = release_230k      # Directory from which to read the files
set recalib = F             # No influence for this version of code
set mock = F                # Selection made from a mock catalogue?
set vlim = F                # Create a volume limited sample?
set mag_fix = F             # Use fixed magnitude limit?
set mu_mask = T             # Use mu mask correction?
set magerr = F              # Apply magnitude errors?
set zzerr = F               # Apply redshift errors?
set spec = F                # Using spectral class information?

# Basic selection criteria
set zmin = 0.002            # Minimum redshift considered
set zmax = 0.3              # Maximum redshift considered
set magmin = 15.0           # Bright apparent magnitude considered
set magmax = 19.35         # Faint apparent magnitude considered
                             # (has no effect unless mag_fix = T)
set compl_cut = 0.5        # Sector completeness cut
set iseed = -75843         # Initial random seed (needs to be
                             # changed when creating a set of
                             # different mock catalogues)
set ng_ranmult = 1         # Multiple of the number of galaxies
                             # produced for the mock catalogues
                             # (if <= 0, no mocks are produced)

set region = sgp            # Region analyzed: ngp, sgp or ran
# The value of region is correctly assigned (within the code) to
# pick up the appropriate input files

# Names of various mask files that are read in
set maskfile = $dirp"_reg/mask.dat"
set maglimmask = $dirp"/maglim_mask.reg.dat"
set mumaskfile = $dirp"_reg/mask_mu.dat"
set selfile = seldir/selfile.$dirp.2df_reg # Selection function file
set catname = $dirp"/parent.reg.txt"      # 2dFGRS catalogue
set file1 = $dirp"_reg/weight.txt"        # 1st list of weights
set file2 = $dirp"_reg/weight_extra.txt"   # 2nd list of weights

# Names of output files:
set outfile1 = "outdir/select_real_"$region".out" # selected data
set outfile2 = "outdir/select_mock_"$region".out" # mock catalogue
```

```

# Additional selection criteria useful only if you want to
# select volume limited subsets of the data, possibly with
# additional selection on magnitudes and eta:
set nlim = 0
# nlim=0 : values of lim_spec (below) ignored
# nlim=1 : construct a volume limited catalogue defined by
# the absolute magnitude limits lim_spec1 & lim_spec2
# nlim=2 : within the volume limit select only galaxies with
# absolute magnitudes between lim_spec3 and lim_spec4
# nlim=3 : within this subset select only galaxies with
# eta value between lim_spec5 and lim_spec6

# This pair of parameters define the limit of the volume
set lim_spec1 = -20.5 # Bright absolute magnitude limit
set lim_spec2 = -20.0 # Faint absolute magnitude limit

# This pair define the absolute magnitude range of the galaxy
# sample that is returned. These magnitude limits must lie within
# the magnitude range (lim_spec1,lim_spec2) that defines the
# sample volume.
set lim_spec3 = -20.5 # Bright absolute magnitude limit
set lim_spec4 = -20.0 # Faint absolute magnitude limit

# This pair allow selection using spectral class information
set lim_spec5 = -5.0 # Lower eta limit
set lim_spec6 = +60.0 # Upper eta limit

```

- **Inputs:** The main input is the galaxy input catalogue (`$dirp/parent.reg.txt`). The format of this file is explained in the [description](#) of the spectral catalogues. Other versions can be created fairly straightforwardly from the mSQL database. The other input files will always be the same (provided you don't change the pixel scale) and therefore do not need to be updated. Currently the pixel scale is set to 1.4arcmin x 1.4arcmin, but can be improved by changing the variables `NPX` and `NPY` (defined in the main programs) accordingly; 1.4' x 1.4' corresponds to `NPX=2*1800` and `NPY=2*600`. Note that the pixel scale needs to be the same as the one used in generating the masks.
- **Outputs:** `select_release.exe` outputs two files - one for the selected data (in `outfile1`) and one for the randoms (in `outfile2`). If you want to change the format of these two files, you can do so by setting the code variable `write_cat=.false.` and inserting your own code at the bottom of program `selectdata` as indicated in the code. The standard format of the output is:

```

ra      = galaxy R.A. (B1950)
dec     = galaxy Dec. (B1950)
zz      = best galaxy redshift
mag     = galaxy b_J magnitude
wsel    = weight assigned by 10 nearest neighbours (equal to 1 if
          all neighbours have a good quality redshift; typically
          equal to 2 if all 10 nearest neighbours are missing)
compl   = completeness of associated sector
selz    = selection function value for galaxy (without mu_mask)
selz_mu = selection function value for galaxy (with mu_mask)
bjlim   = b_J magnitude limit
serial  = galaxy serial number (only for real data, not mocks;
          identical to the one listed in $dirp/parent.reg.txt)

```

- **Notes on the code:**
  - Some additional files are produced by these programs and used at different stages of the analysis; these files are not relevant to the user.
  - There are a few parameters that are set within the main program rather than in the script. These have been set to typical values, but can be changed at the user's discretion (and risk).
  - The program uses a  $\Omega=0.3$ ,  $\Lambda=0.7$  cosmology by default.

## 8.4 Limitations and corrections

- Each pixel in the masks is 1.4 arcmin on a side. This is much larger than the precision of the 2dFGRS galaxy positions. Hence the masks can indicate that some 2dFGRS galaxies are outside the survey boundary or inside excluded holes due to pixelisation effects, as the masks have been defined in a conservative way.
- In the definition of the magnitude-dependent completeness mask in section 8.3 of Colless et al. (2001), there is an error in the value given for the parameter  $\alpha$ ; the paper gives  $\alpha=0.5$ , but the correct value is  $\alpha=0.5\ln(10)$ .

## 9 FITS FILES AND SOFTWARE

The template program below shows how CFITSIO routines can be used to read the data structures (DSS image and 2dFGRS object spectrum, variance array and sky spectrum) in the 2dFGRS database FITS files of each object in the survey. It is designed to be simple, and demonstrates the basic operations required to open the file, read the data in the images and the data in the keywords, and move through the extensions. Trivial routines for data manipulation are provided. The program takes a filename as an argument, determines the number of spectral extensions (number of times observed), and prompts for the spectral extension to read the data from. The template program and the accompanying example program should provide a code base for analyses of the 2dFGRS spectra.

- Template code for reading the FITS files:
  - `2dF_rdbfits.f` (Fortran)
  - `2dF_rdbfits.c` (C)
- Two example Fortran programs for reading and manipulating the data in the FITS files:
  - `specfits.f` prints the object spectrum, variance array and sky spectrum to a text file

- FITSindex.txt is an index to the FITS files in the database (and on the DVDs)

A note for IRAF users: with multiple-extension FITS files, the filename requires the suffix [n], where n is the extension number (primary image is extension 0, spectrum images are extensions 1..spectra). For example, to display the DSS image of 123456.fits, use the command DISPLAY 123456[0] 1. To display the first object spectrum, variance array and sky spectrum, use DISPLAY 123456[1] 2.

## 10 RESPONSE FUNCTION AND FLUX CALIBRATION

The 2dFGRS spectra are not flux-calibrated. The following describes measurements of the average 2dFGRS response function, which allows approximate relative flux calibrations.

The 2dF response function (with the 2dFGRS setup) was measured by observing a set of stars with measured *ugriz* magnitudes from the SDSS. The 2dF spectra were divided by model spectra that matched the magnitudes to determine the relative efficiency as a function of wavelength. The average relative efficiency is plotted in Figure 1. The observations were taken in January 2001 and the results published in Lewis et al. (2002, MNRAS, 333, 279).

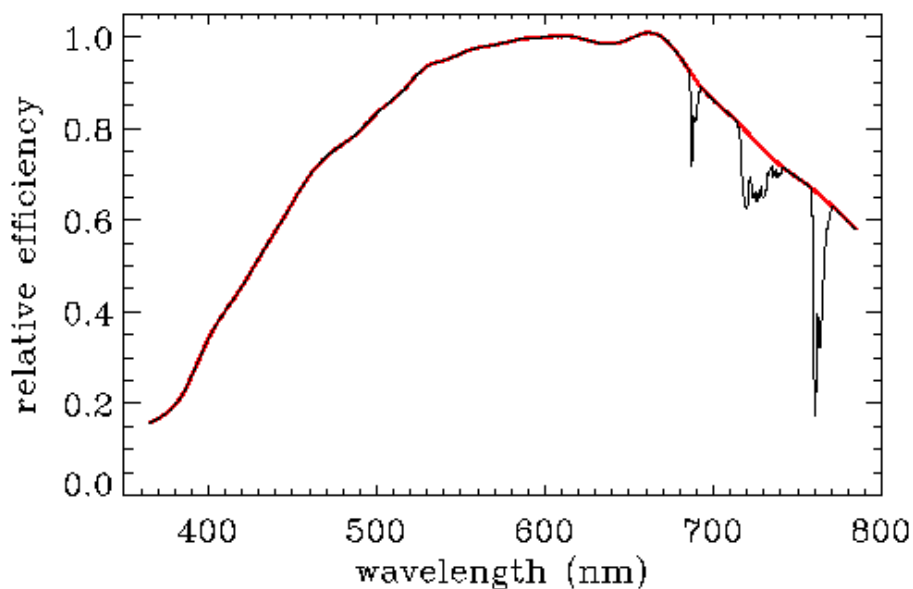


Figure 1: 2dF relative efficiency curve from observations taken in January 2001 (Lewis et al. 2002). The red curve shows the efficiency without the strongest telluric and fibre absorption, while the black curve includes the average absorption from those bands. The data for these curves: `eff-sc.dat` and `eff-all-sc.dat` (notes: Angstroms, efficiency; extrapolation below 3650Å and above 7850Å; corrected to account for differential seeing between wavelengths). Absorption bands only: `eff-telluric.dat`.

The above response curve represents the result of less than one hour of observations. The true average 2dFGRS response function could differ from this due to, for example, response variations over the survey time (1997-2002), unaccounted-for differences between galaxy and stellar observations and inaccuracies in the preliminary SDSS magnitudes. To account for this, we allowed for a spectrophotometric correction for the "constraints on cosmic star-formation history from the cosmic spectrum" (Baldry et al. 2002, ApJ, 569, 582). Some solutions for the 2dF response curve from the best-fit models are shown in Figure 2. Note that the best-fit models are principally constrained by the high pass components of the cosmic spectrum in comparison with the PEGASE population synthesis models. Evidence, that our spectrophotometric correction was in the right direction, came from a comparison of K-corrections and SEDs from previous studies with results for the different 2dFGRS spectral classes using various response corrections (Madgwick et al. 2002, MNRAS, 333, 133).

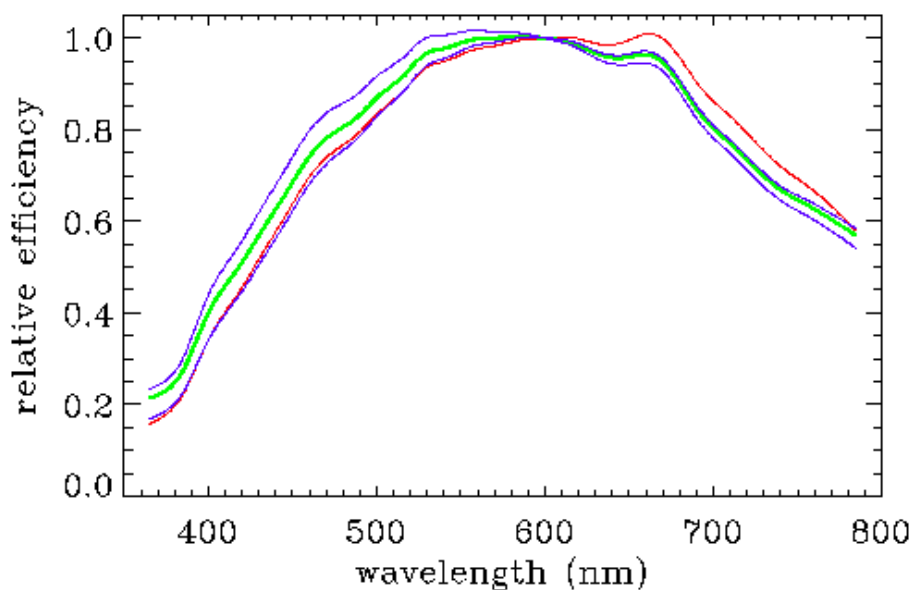


Figure 2: Solutions for the average 2dFGRS response (Baldry et al. 2002). The red curve shows the efficiency from Figure 1. The green and blue curves show a range of efficiency curves after spectrophotometric corrections resulting in good fits to PEGASE model spectra. The data for the curves: `eff-pop-syn-mid.dat`, `eff-pop-syn-min.dat` and `eff-pop-syn-max.dat` (notes: efficiency normalised to 1.0 at 6000Å; telluric and fibre absorption bands not included, see Figure 1).

Conclusions: These response curves can be applied *on average* to give an approximate relative flux calibration for the 2dFGRS spectra. However

the results for individual spectra will vary considerably due to sky subtraction and efficiency variations over each plate. A recommendation would be to use the 'mid.dat' efficiency curve, with the 'min.dat' and 'max.dat' curves providing a systematic uncertainty if required. (N.B. don't forget to include an average telluric absorption correction, if not done on a plate by plate or nightly basis).

Summary of files:

- eff-sc.dat: measured 2dF response excluding strong absorption bands.
- eff-telluric.dat: average profiles of absorption bands.
- eff-all-sc.dat: response including absorption bands.
- eff-pop-syn-min.dat: solution for average 2dFGRS response, minimum deviation from the measured response.
- eff-pop-syn-mid.dat: solution for average 2dFGRS response, mid-range deviation.
- eff-pop-syn-max.dat: solution for average 2dFGRS response, maximum deviation.

## 11 ACKNOWLEDGEMENTS

The 2dF Galaxy Redshift Survey was made possible through the dedicated efforts of the staff of the Anglo-Australian Observatory, both in creating the 2dF instrument and in supporting the survey observations.

## 12 PUBLICATIONS

1. **First Results from the 2dF Galaxy Redshift Survey**  
Colless M.M., 1999, Phil.Trans.Roy.Soc.Lond.A, 357, 105
2. **The 2dF Galaxy Redshift Survey: Spectral Types and Luminosity Functions**  
Folkes S., Ronen S., Price I., Lahav O., Colless M.M., Maddox S.J., Deeley K., Glazebrook K., Bland-Hawthorn J., Cannon R.D., Cole S., Collins C.A., Couch W.J., Driver S.P., Dalton G.B., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Kaiser N., Lewis I., Lumsden S., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 1999, MNRAS, 308, 459
3. **A Measurement of the Cosmological Mass Density from Clustering in the 2dF Galaxy Redshift Survey**  
Peacock J.A., Cole S., Norberg P., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., Deeley K., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I., Lumsden S., Maddox S.J., Percival W.J., Peterson B.A., Price I., Sutherland W.J., Taylor K., 2001, Nature, 410, 169
4. **The 2dF Galaxy Redshift Survey: The Number and Luminosity Density of Galaxies**  
Cross N., Driver S.P., Couch W.J., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S., Colless M.M., Collins C.A., Dalton G.B., Deeley K., De Propriis R., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I., Lumsden S., Maddox S.J., Madgwick D., Moody S., Norberg P., Peacock J.A., Peterson B.A., Price I., Sutherland W.J., Tadros H., Taylor K., 2001, MNRAS, 324, 825
5. **The 2dF Galaxy Redshift Survey: Near Infrared Galaxy Luminosity Functions**  
Cole S., Norberg P., Baugh C.M., Frenk C.S., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Colless M.M., Collins C.A., Couch W.J., Cross N., Dalton G.B., De Propriis R., Driver S.P., Efstathiou G., Jackson C.A., Lahav O., Lewis I., Lumsden S., Maddox S.J., Madgwick D., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2001, MNRAS, 326, 255
6. **The 2dF Galaxy Redshift Survey: The Power Spectrum and the Matter Content of the Universe**  
Percival W.J., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I., Lumsden S., Maddox S.J., Moody S., Norberg P., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2001, MNRAS, 327, 1297
7. **The 2dF Galaxy Redshift Survey: Luminosity Dependence of Galaxy Clustering**  
Norberg P., Baugh C.M., Hawkins E., Maddox S.J., Peacock J.A., Cole S., Frenk C.S., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I., Lumsden S., Peterson B.A., Sutherland W.J., Taylor K., 2001, MNRAS, 328, 64
8. **The 2dF Galaxy Redshift Survey: Spectra and Redshifts**  
Colless M.M., Dalton G.B., Maddox S.J., Sutherland W.J., Norberg P., Cole S.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Collins C.A., Couch W.J., Cross N., Deeley K., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Madgwick D.S., Peacock J.A., Peterson B.A., Price I.A., Seaborne M., Taylor K., 2001, MNRAS, 328, 1039
9. **The 2dF Galaxy Redshift Survey: A Study of Catalogued Clusters of Galaxies**  
De Propriis R., Couch W.J., Colless M.M., Dalton G.B., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S., Collins C.A., Cross N., Deeley K., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I., Lumsden S., Maddox S.J., Madgwick D., Moody S., Norberg P., Peacock J.A., Peterson B.A., Price I., Sutherland W.J., Tadros H., Taylor K., 2002, MNRAS, 329, 87
10. **Radio sources in the 2dF Galaxy Redshift Survey - II. Local radio luminosity functions for AGN and star-forming galaxies at 1.4GHz**  
Sadler E.M., Jackson C.A., Cannon R.D., McIntyre V.J., Murphy T., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Lahav O., Lewis I., Lumsden S., Maddox S.J., Madgwick D., Norberg P., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 329, 227
11. **The 2dF Galaxy Redshift Survey: The Population of Nearby Radio Galaxies at the 1mJy level**  
Magliocchetti M., Maddox S.J., Jackson C.A., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Lahav O., Lewis I.J., Lumsden S., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 333, 100
12. **The 2dF Galaxy Redshift Survey: Galaxy Luminosity Functions per Spectral Type**  
Madgwick D.S., Lahav O., Baldry I., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lewis I.J., Lumsden S., Maddox S.J., Norberg P., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 333, 133
13. **Evidence for a Non-Zero Lambda and a Low Matter Density from a Combined Analysis of the 2dF Galaxy Redshift Survey and Cosmic Microwave Background Anisotropies**  
Efstathiou G., Moody S., Baugh C., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propriis R., Driver S.P., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Maddox S.J., Norberg P., Peacock J.A., Percival W.J., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 330, 29
14. **The 2dF Galaxy Redshift Survey: Constraints on Cosmic Star-Formation History from the Cosmic Spectrum**  
Baldry I.K., Glazebrook K., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propriis R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Hawkins E., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Maddox S.J., Madgwick D.S., Norberg P., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, ApJ, 569, 582

15. **The 2dF Galaxy Redshift Survey: The  $b_j$ -band galaxy luminosity function and survey selection function**  
Norberg P., Cole S.M., Baugh C.M., Frenk C.S., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Colless M.M., Collins C.A., Couch W.J., Cross N.J.G., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Maddox S.J., Madgwick D.S., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 336, 907
16. **The 2dF Galaxy Redshift Survey: The dependence of galaxy clustering on luminosity and spectral type**  
Norberg P., Baugh C.M., Hawkins E., Maddox S., Madgwick D., Lahav O., Cole S.M., Frenk C.S., Baldry I., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Glazebrook K., Jackson C.A., Lewis I.J., Lumsden S., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 332, 827
17. **The 2dF Galaxy Redshift Survey: The bias of galaxies and the density of the Universe**  
Verde L., Heavens A.F., Percival W.J., Matarrese S., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Maddox S.J., Madgwick D.S., Norberg P., Peacock J.A., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 335, 432
18. **The 2dF Galaxy Redshift Survey: The amplitudes of fluctuations in the 2dFGRS and the CMB, and the implications for galaxy biasing**  
Lahav O., Bridle S.L., Percival W.J., Peacock J.A., Efstathiou G., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lewis I.J., Lumsden S., Maddox S.J., Madgwick D.S., Moody S., Norberg P., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 333, 961
19. **The 2dF Galaxy Redshift Survey: The environmental dependence of galaxy star formation rates near clusters**  
Lewis I.J., Balogh M., De Propris R., Couch W.J., Bower R., Offer A., Bland-Hawthorn J., Baldry I.K., Baugh C.M., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Cross N., Dalton G.B., Deeley K., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Hawkins E., Jackson C.A., Lahav O., Lumsden S., Maddox S.J., Madgwick D.S., Norberg P., Peacock J.A., Percival W., Peterson B.A., Sutherland W.J., Taylor K., 2002, MNRAS, 334, 673
20. **New upper limit on the total neutrino mass from the 2dF Galaxy Redshift Survey**  
Elgaroy O., Lahav O., Percival W.J., Peacock J.A., Madgwick D.S., Bridle S.L., Baldry I.K., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lewis I.J., Lumsden S., Maddox S.J., Norberg P., Peterson B.A., Sutherland W.J., Taylor K., 2002, Phys.Rev.Lett., 89, 061301
21. **Parameter constraints for flat cosmologies from CMB and 2dFGRS power spectra**  
Percival W.J., Sutherland W.J., Peacock J.A., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S.M., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Maddox S.J., Moody S., Norberg P., Peterson B.A., Taylor K., 2002, MNRAS, 337, 1068
22. **The 2dF Galaxy Redshift Survey: correlation functions, peculiar velocities and the matter density of the universe**  
Hawkins E., Maddox S.J., Cole S., Madgwick D.S., Norberg P., Peacock J.A., Baldry I.K., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Jones B., Lahav O., Lewis I.J., Lumsden S., Percival W., Peterson B.A., Sutherland W., Taylor K., 2003, MNRAS, in press
23. **The 2dF Galaxy Redshift Survey: the luminosity function of cluster galaxies**  
De Propris R., Colless M.M., Driver S.P., Couch W.J., Peacock J.A., Baldry I.K., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S., Collins C.A., Cross N., Dalton G.B., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Hawkins E., Jackson C.A., Lahav O., Lewis I.J., Lumsden S., Maddox S.J., Madgwick D.S., Norberg P., Percival W., Peterson B.A., Sutherland W., Taylor K., 2003, MNRAS, 342, 725
24. **The 2dF Galaxy Redshift Survey: galaxy clustering per spectral type**  
Madgwick D.S., Hawkins E., Lahav O., Maddox S.J., Norberg P., Peacock J.A., Baldry I.K., Baugh C.M., Bland-Hawthorn J., Bridges T.J., Cannon R.D., Cole S., Colless M.M., Collins C.A., Couch W.J., Dalton G.B., De Propris R., Driver S.P., Efstathiou G., Ellis R.S., Frenk C.S., Glazebrook K., Jackson C.A., Lewis I.J., Lumsden S., Peterson B.A., Sutherland W., Taylor K., 2003, MNRAS, in press