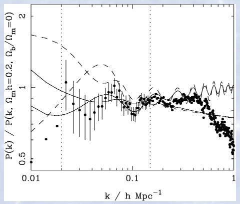
The 2dF Galaxy Redshift Survey

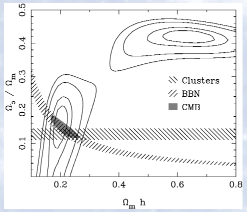
Cosmology and the 2dFGRS

The 2dFGRS was designed to build on previous studies of the large-scale structure in the galaxy distribution, with the following main aims:

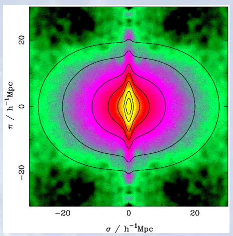
- To measure the galaxy power spectrum P(k) on scales up to a few hundred Mpc, bridging the gap between the scales of nonlinear structure and measurements from the the cosmic microwave background (CMB).
- To measure the redshift-space distortion of the large-scale clustering that results from the peculiar velocity field produced by the mass distribution.
- To measure higher-order clustering statistics in order to understand biased galaxy formation, and to test whether the galaxy distribution on large scales is a Gaussian random field.



The large-scale power spectrum can be measured to perhaps 10% precision. In order to bring out the details of the result, it is convenient to show the power ratioed to a particular form of the Cold Dark Matter power spectrum (with Ω h = 0.2, scale-invariant n = 1 primordial fluctuations, and a normalization of $\sigma_8 = 1$). The data are plotted as a function of scale against wavenumber: k = 2π / λ, where λ is wavelength. The measurements are most reliable for wavelengths up to 300 h^{-1} Mpc (h = H / 100 km s^{-1} Mpc^{-1}) - or about 1.4 billion light years, using h = 0.7 as a best guess.



What is especially interesting is that the data display small deviations from a smooth curve, and these are interpreted as acoustic oscillations in the primordial matter-radiation fluid. They allow us to infer that about 15% of the matter in the universe is baryonic, while the rest is collisionless dark matter. The total amount of matter is well constrained at about 30% of the critical density, again assuming a Hubble parameter of h = 0.7. This is shown in the likelihood contours, which compare the 2dFGRS result to constraints from X-ray cluster analysis, big-bang nucleosynthesis, and anisotropies in the Cosmic Microwave Background.

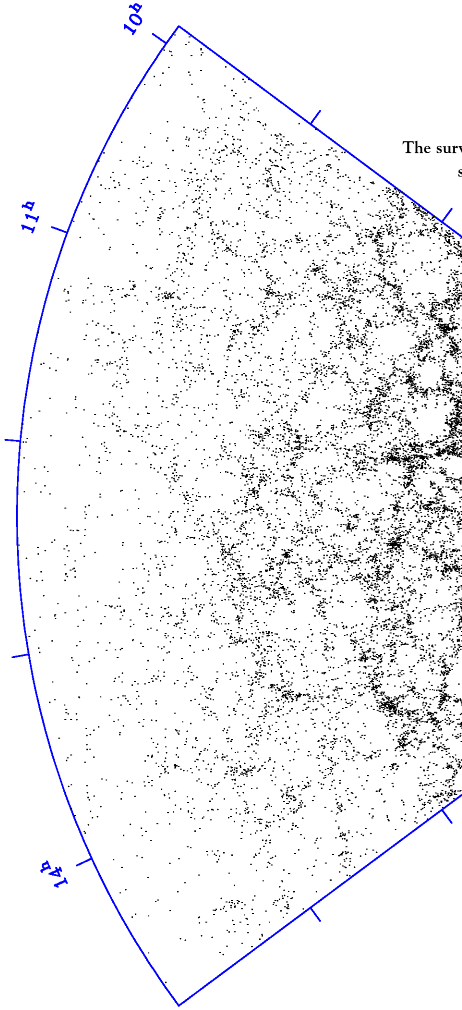
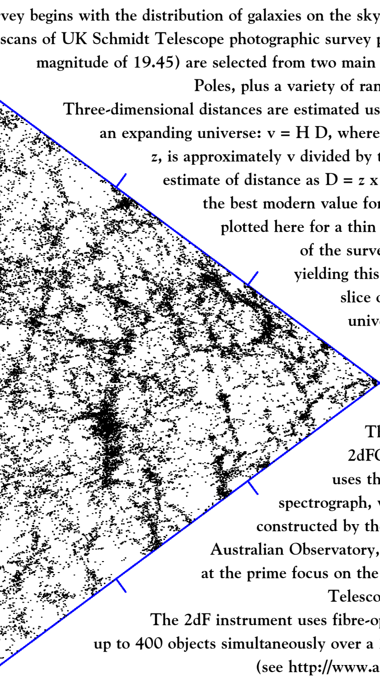
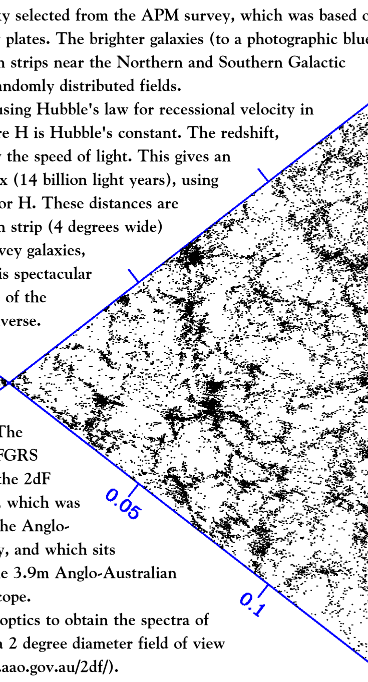
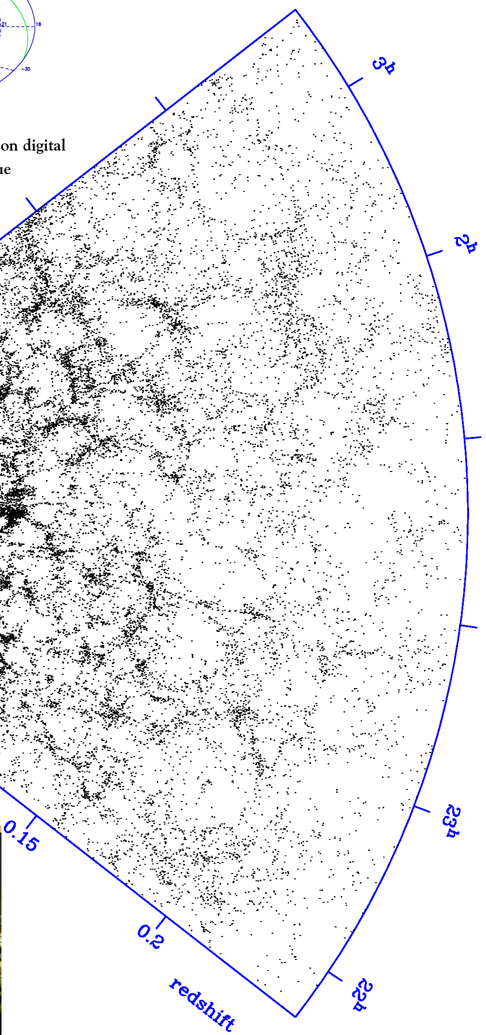


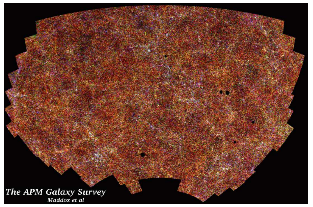
The simplest statistic for studying redshift distortions in the clustering pattern is the the two-point correlation function, $\xi(\sigma,\pi)$. This measures the excess probability over random of finding a pair of galaxies with a separation in the plane of the sky σ and a line-of-sight separation π. Because the radial separation in redshift space includes the peculiar velocity as well as the spatial separation, $\xi(\sigma,\pi)$ will be anisotropic. On small scales the correlation function is extended in the radial direction due to the large peculiar velocities in non-linear structures such as groups and clusters -- this is the well-known `Finger-of-God' effect. On large scales it is compressed in the radial direction due to the coherent infall of galaxies onto mass concentrations.

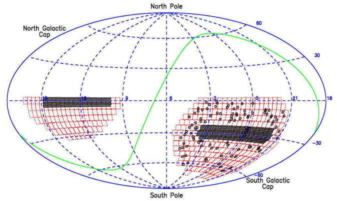
The redshift-space correlation function for the 2dFGRS displays very clearly these two signatures of redshift-space distortions. The degree of large-scale flattening is determined by the total mass density parameter, Ω, and the biasing of the galaxy distribution. On large scales, it should be correct to assume a linear bias model, so that the redshift-space distortion on large scales depends on the combination $\beta = \Omega^{0.6} / b$, The 2dFGRS figure is $\beta = 0.43 \pm 0.07$, showing that galaxies are nearly unbiased on large scales, if $\Omega = 0.3$.

Mapping The Universe

This picture shows the distribution of approximately 75,000 galaxies from the 2dF Galaxy Redshift Survey (2dFGRS). This survey was the first to measure the three-dimensional positions of over 100,000 galaxies, and will reach a total of about 250,000. The aim is to map the large-scale structure in the galaxy distribution, which is widely seen as one of the most important relics from an early stage of evolution of the universe.





The survey begins with the distribution of galaxies on the sky selected from the APM survey, which was based on digital scans of UK Schmidt Telescope photographic survey plates. The brighter galaxies (to a photographic blue magnitude of 19.45) are selected from two main strips near the Northern and Southern Galactic Poles, plus a variety of randomly distributed fields. Three-dimensional distances are estimated using Hubble's law for recessional velocity in an expanding universe: v = H D, where H is Hubble's constant. The redshift, z, is approximately v divided by the speed of light. This gives an estimate of distance as D = z x (14 billion light years), using the best modern value for H. These distances are plotted here for a thin strip (4 degrees wide) of the survey galaxies, yielding this spectacular slice of the universe.

The 2dFGRS uses the 2dF spectrograph, which was constructed by the Anglo-Australian Observatory, and which sits at the prime focus on the 3.9m Anglo-Australian Telescope.

The 2dF instrument uses fibre-optics to obtain the spectra of up to 400 objects simultaneously over a 2 degree diameter field of view (see http://www.aao.gov.au/2df/).

A robotic positioner automatically moves the fibre heads, which are held to the field plate (approximately 0.5m diameter) by magnetic buttons. It takes less than one hour to re-configure a complete field. There are two field plates, one of which observes while the other is being re-configured, so the observations can proceed with no dead time, taking 400 redshifts per hour in ideal conditions.

The 2dFGRS team: Anglo-Australian Observatory - Joss Bland-Hawthorn, Terry Bridges, Russell Cannon, Ian Lewis; Australian National University - Matthew Colless, Carole Jackson, Bruce Peterson; California Institute of Technology - Richard Ellis, Keith Taylor; Johns Hopkins University - Ivan Baldry, Karl Glazebrook; Liverpool John Moores University - Chris Collins; University of Cambridge - George Efstathiou, Ofer Lahav, Darren Madgwick; University of Durham - Carlton Baugh, Shaun Cole, Carlos Frenk, Peder Norberg; University of Edinburgh - John Peacock, Will Percival, Will Sutherland; University of Leeds - Stuart Lumsden; University of New South Wales - Warrick Couch, Roberto de Propris; University of Nottingham - Edward Hawkins, Steve Maddox; University of Oxford - Gavin Dalton; University of St Andrews - Nicholas Cross, Simon Driver

http://www.mso.anu.edu/2dFGRS/