First Results from the Hitchhiker CCD Sky Survey

Hitchhiker is a parallel twin CCD camera mounted on the William Herschel Telescope at La Palma. It operates in parallel with scheduled spectroscopic observers by means of a special pick-off mirror and optics which enable it to image an off-axis region of the telescope's field of view. Observations are made simultaneously in two bands (usually B and R or V and I) by means of a dichroic beam splitter. (See Wide-field Imaging Newsletter No. 1 for more details).

Hitchhiker (HH) was commissioned in November 1990 and data for the 8 runs (1 – 2 weeks each in dark/grey time) in the first year have now been reduced and archived. Naturally, because of its parallel nature, the HH sky survey is entirely serendipitous in terms of the fields surveyed, and exposure times per field vary enormously.

The first scientific output, which we report on here, comes from the analysis of a single high Galactic latitude field for which particularly long exposures were obtained, viz. 2 hours in B and R and another half hour in V and I. There are about 10 more fields with exposures of order an hour or more in the first year's data. Both because of their current scientific interest and as a stringent test of HH's capabilities and performance we have concentrated so far on producing deep galaxy number counts in each band and the corresponding faint galaxy colour distributions.

The CCD data is reduced by a combination of standard and instrument specific routines. The most important are flat fielding, background subtraction and dust subtraction. Flat fielding was achieved by using a median night sky frame built from a stack of many (~ 80) suitably normalized (mostly empty) deep frames from the HH archive. HH frames suffer from vignetting patterns in their outer regions so background subtraction is vital. This was performed by fitting a bi-cubic spline surface to a grid of points representing the local median sky values on a given frame and subtracting this surface from the data. This is superior to simply subtracting a smoothed version of the data frame since median filtering does not spread out large images and leave artefacts in the subtracted data. Also, because one of the HH lenses is near a focal plane of the instrument any dust on this lens leaves ring shaped depressions in the final image. These artefacts were cured by obtaining a smoothed version of a frame containing only the negative fluctuations below sky. This combination of procedures flattened the sky to an rms scatter of only 0.3% in the best case (the R frame — the CCD is less efficient in the B so there is considerably more Poisson noise).

Finally we have used FOCAS for the image detection and parameterization. We set a low isophotal threshold but count only those objects with signal-to-noise (S/N) ratio (inside the limiting isophote) of at least 7.5. Notice that this is not the same thing as having a pure magnitude limit, compact objects of a given magnitude have higher S/N than corresponding lower surface brightness images. It does, though, reflect how images are really detected. In total we have 526 objects to B = 26.4, 283 objects to V = 24.9, 1151 objects to R = 26.3 and 195 objects to I = 22.5 in our final image catalogues for the four bands. From analysis of the sizes and surface brightness of the images we estimate that we are complete (i.e. the S/N limit does not cause the loss of a significant number of objects) to limits about half a magnitude brighter than these quoted values (which obviously refer to compact star-like images). The numbers and number magnitude count slopes are in excellent agreement with previous workers and it appears that this is the first time that a single field has been studied to this depth in all four bands.

We also have colour information on the objects which have matching images on more than one frame. The B–V and V–R colour histograms show the well known trends for fainter galaxies to be bluer on average, but the V–R colour shows no sign of a similar trend, possibly suggesting that we are not seeing many high redshift objects (where we would be seeing essentially rest frame U–B). Interestingly in R–I we see a population of very red objects which are consistent with non-evolving or passively evolving early type giant galaxies at moderately high z.

In summary, the serendipitous HH CCD survey has been able to reach magnitude limits competitive with all but the very largest programmes of deep CCD imaging of faint galaxies. We have another 10 fields available, just from year 1, and are thus in a position now to start looking at field to field variations in numbers and colours. HH is currently being refurbished and the third year of observations will begin early in 1993.

Simon Driver and Steve Phillipps
Department of Physics and Astronomy
University of Wales College of Cardiff
PO Box 913
Cardiff CF2 3YB
Wales
U.K.

Galaxy Clustering at B ~ 25^m

The angular two-point correlation function, $\omega(\theta)$, for galaxies can be used as a probe of their redshift distribution N(z) and, therefore, of galaxy luminosity evolution. Without redshift data, we can still observe the projection onto the two-dimensional sky of the three-dimensional clustering of galaxies. The autocorrelation of this projected distribution is described by $\omega(\theta)$. Observations have indicated that $\omega(\theta)$ follows a $\theta^{-0.8}$ power-law (Peebles 1980) and that the index of the power-law remains approximately constant to the faintest limits of photographic surveys (Jones, Shanks & Fong 1987) The $\omega(\theta)$ amplitude is related to the amplitude of the 3-dimensional two-point correlation function $\xi(r)$ by means of an integration over N(z) using Limber's formula (see, for example, Phillipps et al. 1978).

The scaling of the $\omega(\theta)$ amplitude for the galaxies with survey depth will therefore relate to the change with depth of N(z). The wider the range of redshifts over which galaxies are distributed the more the observable clustering will be diluted by projection.

Here we estimate the $\omega(\theta)$ amplitude and investigate its scaling for 4540 galaxies observed on 12 CCD frames (total area 284 arcmin^2) at the INT. These data were published as number counts by Metcalfe et al. (1991) and is limited at $B_{ccd} < 25.0$.

The $\omega(\theta)$ was calculated as described by Infante (1990) and Efstathiou et al. (1991) using a local normalization of the galaxy number density for each field. The resulting $\omega(\theta)$ for all $B_{ccd} \leq 25.0$ galaxies in this survey was fitted with a function 'A($\theta^{-0.8}$ - 16.1)' which gave the $\theta^{-0.8}$ power-law amplitude at one degree, corrected for 'integral constraint'. The result was $(4.124 \pm 2.044) \times 10^{-4}$ (field-to-field errors), consistent with the $\omega(\theta)$ results given by Efstathiou et al. (1991) for the deep CCD fields of Tyson (1988). The $\omega(\theta)$ amplitude can similarly be estimated for brighter subsets of our data catalogue, enabling its scaling to be investigated over magnitude limits in the range $23.25 \leq B_{ccd} \leq 25.00$.

In addition we have a new result from the single deeper field described by Metcalfe, Shanks & Fong (1991) in which 1442 galaxies were detected to $B_{ccd} = 27.0$. This gave an even lower clustering amplitude of $(2.971 \pm 1.525) \times 10^{-4}$.

The graph shows our correlation amplitudes for different magnitude limits, compared with those obtained from other surveys. For details of these earlier results see Stevenson et al. (1985), Jones et al. (1987), Koo & Szalay (1984), Infante (1990) and Efstathiou et al. (1991). Our correlation amplitudes appear to be consistent with the photographic data to the final limits of such surveys ($B \approx 24$).

We also compare our results with the predictions of two models, differing only in the evolution with redshift of the characteristic galaxy luminosity L^*. A correlation radius of $r_0 = 4.3h^{-1}$Mpc (fitting the Zwicky catalogue clustering at brighter limits) and a value for q_0 of 0.05 were used. A model without luminosity evolution was computed using the k-corrections given by