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Dwarf Galaxies at Moderate Redshifts

Redshift Surveys have shown that there may be very large populations of dwarf galaxies at moderate redshifts, say 0.2 to 0.5, which are probably absent today. Various pictures of galaxy evolution have been envisioned to account for this apparently dramatic secular change in the field galaxy luminosity function. However, while it is known that many rich nearby clusters possess large dwarf galaxy populations today, surprisingly little is known directly about the low luminosity galaxy population in clusters at earlier epochs (i.e. at higher redshifts). Attention in these clusters, as far as evolution goes, has generally been concentrated on the Butcher-Oemler effect, i.e. the fraction of blue galaxies among the brighter members, and on the spectroscopy of objects such as the so-called post-starburst galaxies, again among the brighter cluster members.

To try and remedy this situation, we have utilised data obtained as part of the Hitchhiker CCD Sky Survey (see Newsletter No. 3, p. 6) for a detailed examination of a moderate redshift cluster. Hitchhiker operates on the William Herschel Telescope on La Palma in parallel with scheduled spectroscopic observers (see Newsletter No. 1, p. 37) and is one of the few CCD survey instruments so far in operation. The data in question here was a rare pointed observation, made in discretionary time, rather than the usual serendipitous operation of the instrument, of the cluster Abell 963 ($z = 0.206$). Simultaneous 40 minute exposures in the B and R bands were obtained for a field approximately 3′ by 5′ (400 by 650 kpc) centred about 3′ (400 kpc) from the central cD galaxy (which thus appears in a corner of the frame).

Hitchhiker's CCDs are much more efficient in the red than the blue, so we will henceforth concentrate on the R band data. After carefully flat fielding the data (see Driver et al. 1994a for details), objects were detected using the FOCAS package. The detection limit was set at 12 contiguous pixels (1 square arc second) above a limiting isophote of 27 magnitudes per square arc second and a minimum S/N of 7.5. The data are complete down to a (total) magnitude limit $R = 24.5$, corresponding to an intrinsic red magnitude around -16.5 at the cluster. Magnitudes were corrected from isophotal to 'total' using realistic simulated frames to determine empirical correction factors. (Notice that the isophotal magnitudes can be as faint as 26 given our selection criteria). Comparison of our photometry with existing data in the range $R = 18$ to 21 (the brightest 50 Hitchhiker galaxies)

indicates a scatter of around 0.10 magnitudes and no scale error (see Driver et al. 1994b for more details).

To subtract the expected background contamination we have used the corresponding mean counts taken from the random field survey of Driver et al. (1994a), allowing both for Poisson errors in the counting statistics and possible 20 percent field to field variations due to clustering. Even with the largest allowable background subtracted, we still see a strong excess signal (of order of a factor 2) in the counts right down to the faint limit of the survey. We can fit this excess (i.e. the magnitude distribution for the cluster galaxies) very well by a conventional flat Schechter function at the bright end plus a turn up at fainter magnitudes due to a second, dwarf, population with a steep luminosity function slope (around -1.8). Notice that the R band k-corrections are more or less independent of morphological type (unlike those in the blue) so that the observed magnitude distribution maps directly to the true (rest frame) red luminosity function.

The shape of the LF thus determined turns out to agree very closely with that seen at faint magnitudes in the nearby rich clusters Coma and Abell 1367. This suggests that contrary to the situation in the field and among bright cluster galaxies, there has been little evolution in the faint cluster galaxy population over the lookback time of a few Gyr. However, this remains to be tested with a larger sample of clusters at a range of redshifts. Such a programme of observations is now in hand on the Anglo-Australian Telescope.

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