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Low Surface Brightness Dwarf Galaxies in Nearby Clusters

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Abstract. We present initial results of a study of low surface brightness dwarf galaxies within galaxy clusters at $z \leq .03$ as part of our program to determine the clustering properties, luminosity functions, and morphologies of dwarf galaxies in a wider range of cluster environments. In addition to deep V-band images covering up to 1 deg^2 in each of 13 different clusters, we have obtained velocities from fiber spectroscopy for 235 galaxies in A3526. In A3526, we find a drop in cluster galaxy counts at intermediate magnitudes which is supported by our spectroscopic results.

1. Introduction

Dwarf galaxies are the most common type of galaxy thus far discovered and may be substantial contributors of mass to the universe. They also provide important clues to understanding galaxy structure, formation, and evolution, and are ideal candidates for probing environmental effects in galaxy clusters.

We are deriving galaxy luminosity functions (LFs) for 13 nearby clusters. Results of previous studies find widely varying values for the faint-end LF slope (Bernstein et al. 1995, Trentham et al. 1998, de Propris et al. 1995) which may be due to different treatments of the selection effects inherent in detecting these low surface brightness systems. Different cluster environments, however, may play a significant role in determining the abundance and morphologies of member galaxies causing intrinsic cluster-to-cluster variations in the LF. With our large data set, and utilizing the same method for each cluster, we will be able to ascertain whether this is the case. A thorough understanding of the faint-end slope will determine whether dwarfs (and their associated dark matter halos) can account for a substantial fraction of the cluster dark matter content.

We are also studying environmental influences on dwarf properties. Morphology, luminosity, structure (such as existence of a nucleus), and surface brightness may all be affected by environmental factors. With our large areal coverage, we shall look at dwarf / giant ratios and the dwarf properties with respect to their spatial distributions within each cluster and in comparison between different clusters to determine which factors most influence dwarf populations.

2. Observations and Methods

Observations of 13 galaxy clusters were acquired between 1993 and 1997 on the LCO 1m, CTIO 1.5m and 4m, and MDM 1.3m telescopes. Deep ($\sim$ 1 hour)

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V-band images were taken for each cluster in a mosaic pattern achieving total coverage for each of $\geq .5$ deg^2. A spectroscopic follow-up was made of the brightest 500 galaxies in A3526 using the LCO 2.5m with a 2D Frutti + fibers reaching cluster galaxies as faint as $M_V = -14$ (for $H_0 = 75$ km/s/Mpc). We used two software packages, FOCAS (Valdez 1989) and SExtractor (Bertin & Arnouts 1996), to detect and classify objects. Control fields, which were observed 3 degrees away from each cluster, were reduced in exactly the same manner and were used to determine the contribution of background galaxies. We are addressing incompleteness and selection effects through false galaxy analysis.

3. Luminosity Function of A3526

Fig. 1 shows the LF for A3526 after subtraction of background galaxy counts. These background counts were determined both from our control fields and from our spectroscopic data. We have corrected the field size for the areal coverage of large galaxies, but have yet to correct the counts for incompleteness. It is readily apparent that incompleteness sets in by $m_V = 22$ ($M_V = -11$). More importantly, between $19.5 < m_V < 21.5$ there is an excess of control field counts over the cluster counts.

We investigated several possibilities for this anomalous behavior. One possibility is that our control fields landed on regions of higher background density. Field counts can vary up to 25%, even in nearby regions (Picard 1991), so by lowering our control field counts 25%, we get an upper limit for the faint-end slope of the cluster LF of $\alpha = -1.14$. Other possibilites for this apparent truncation of the LF include selection effects which cause us to miss a particular population of LSB galaxies, or that FOCAS and SExtractor are splitting up the larger LSB galaxies. We are addressing these concerns with false galaxy tests.

To estimate the LF from our spectral results, we determined the fraction of members / non-members in each magnitude bin. These were corrected to include as members those galaxies with spectra from which velocities were not extracted but which fell within a surface brightness - size region of other proven members. Using these fractions, along with the total number of galaxies detected in the cluster fields, we calculated the expected number of members in each magnitude bin. In fig. 1 it can be seen that these results match those from statistical subtraction of background galaxies quite well, and thus supports a genuine drop-off in membership at $m_V = 18.5$.

In other recent spectroscopic studies of cluster dwarfs by Adami et al. (1998) and Secker et al. (1998) Coma dwarf candidate spectra turned up far fewer dwarf members than was expected based on the cluster luminosity function as determined by Bernstein et al. (1995) and Secker. Between the two studies, of the program candidates which yielded velocities, only 20-45% of the expected number of members turned out to be members placing concerns as to the validity of control field statistical subtraction. While our photometric and spectroscopic results do agree, these 3 studies finding a flattening of the LF may contradict work finding steeper slopes at intermediate magnitudes.

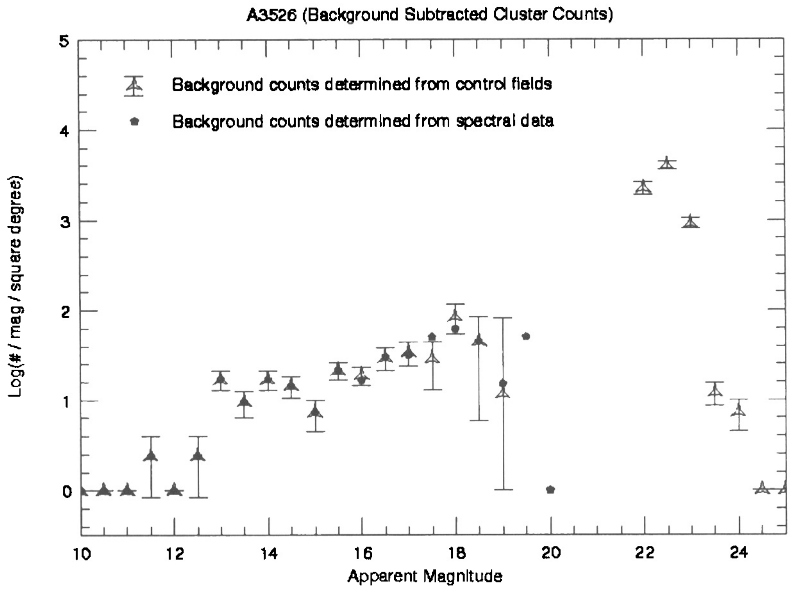

Figure 1. Open triangles show cluster member counts after subtraction of the control field counts while solid symbols represent counts determined from spectroscopic membership results. For clarity, error bars are only supplied for the former method. Neither spectra nor control field counts find background galaxies with $m_V < 16$, and the spectra were only obtained up to $m_V = 20$. The two member populations agree remarkably well. Both show a drop in member counts at $m_V \sim 18.5$ supporting a truncation of the LF (assuming selection effects are not to blame).

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