PHOTOMETRY AND SPECTROSCOPY OF COMA DWARF ELLIPTICALS

JEFF SECKER
Program in Astronomy, Washington State University, Pullman, WA 99164-3113
USA

WILLIAM E. HARRIS
Department of Physics and Astronomy, McMaster University, Hamilton, Ontario
L8S 4M1 Canada

PAT CÔTÉ and J.B. OKE
California Institute of Technology, Pasadena, CA 91125 USA,
and
Dominion Astrophysical Observatory, National Research Council, 5071 W. Saanich Rd., Victoria, BC V8X 4M6 Canada

1 Destruction of Faint Dwarf Ellipticals in the Core

We have used deep $B -$ and $R -$band CCD images (with $\approx 1.2''$ seeing) of the central $\approx 700$ arcmin$^2$ of the Coma cluster core (and an associated $\approx 270$ arcmin$^2$ control field) to study the early-type dwarf elliptical (dE) galaxy population (Secker & Harris 1997; Secker, Harris & Plummer 1997). In the left panel of Fig. 1, we plot a subset of the total cluster field CMD: the galaxy sequence is clearly visible, with the dEs beginning at $R \approx 15.5$ mag and a mean color of $(B - R) \approx 1.54$ mag. The larger solid circles represent the trimmed median $(B - R)$ color in one-magnitude bins over the entire luminosity range, and the solid line illustrates the least-squares regression line fit to median color values in the range $14 < R < 18.5$ mag. This provides an excellent fit, and the bright part of the early-type galaxy sequence shows a strong trend for fainter dE galaxies to have (on average) a bluer color: $\Delta(B - R)/\Delta R = -0.056 \pm 0.002$. Fainter than $R \approx 18.5$ mag, the dE sequence spreads and merges with the multitude of noncluster galaxies, which are the dominant population at these magnitudes. The effect is that the program-field mean color values are skewed redward, away from the dashed line (an extension of the upper solid line), towards the mean colors of the control-field objects (open circles).

In the right panel of Fig. 1, we plot the binned, scaled and subtracted CMD: one vertical line segment for each color-magnitude bin, with a height proportional to the number of objects in that bin. Here, the solid circles represent the mean corrected color, weighted by the number of objects in each
Figure 1: Analysis of the control-field corrected program-field CMD.

The regression line from the left panel is reproduced here, together with the extrapolated dotted line: it provides an excellent fit to the corrected mean color values of the dE galaxy sequence, over the full range $15.5 \leq R \leq 22.5$ mag. Thus the apparent reddening of the dE sequence in the left panel is attributed entirely to contamination of the cluster sample.

Using the color-metallicity relationship derived from metallicities and integrated colors for Galactic globular clusters, valid over the range $-2.4 \leq [\text{Fe/H}] \leq -0.2$ (Harris 1996), we obtain $\Delta [\text{Fe/H}] / \Delta R = -0.19 \pm 0.01$ dex for our sample of Coma dEs. Cellone, Forte & Geisler (1994) plot a $T_1$, $(C-T_1)$ CMD (Washington filters; $T_1 \simeq R$) for a sample of 14 Fornax dEs. From a linear fit to their tabulated data points, and the color-metallicity relationship of Geisler & Forte (1990), we calculate $\Delta [\text{Fe/H}] / \Delta T_1 = -0.18 \pm 0.07$ dex for these Fornax dEs. These slopes are formally consistent, suggesting that the process of dE galaxy formation is very similar in these very different cluster environments.

We have also analyzed the completeness-corrected background-subtracted radial number density profiles of bright and faint galaxies in the cluster core. Our bright sample includes 280 cluster galaxies, a subsample selected to have $0.7 \leq (B-R) \leq 1.9$ mag and $R \leq 19.0$ mag (giants plus bright dEs). Our faint
sample includes 2246 objects selected to have $0.7 \leq (B - R) \leq 1.9$ mag and $19.0 < R \leq 22.5$ mag. For the bright galaxy sample, the best-fit King model has a core radius $R_c = 13.7$ arcmin, significantly smaller than $R_c = 22.2$ arcmin found for the faint dEs. Lobo et al. (1997) analyzed the faint-end slope of the galaxy luminosity function in Coma, and determined that it is shallower in the core than for the cluster as a whole. This is consistent with the dynamical destruction of dE galaxies in the dense environment of the cluster core. Our results presented above are also consistent with this hypothesis:

(1) Thompson & Gregory (1993) proposed that the core of the Coma cluster is deficient in the number of faint dE galaxies, and they argued that tidal disruption could be responsible for partially destroying this low-mass population. Our study indicates that the larger core radius for faint dEs is genuine, and in this sense the cluster core is deficient in the number of faint dEs.

(2) Mattila (1977) measured the color of the diffuse intergalactic component of the Coma cluster light, and obtained $(B - V) = 0.54 \pm 0.18$ mag. From the right panel of Fig. 1, we estimate $(B - R) \simeq 1.15$ mag for our faintest dEs ($R = 22.5$ mag), corresponding to $(B - V) \simeq 0.70$ mag, which is within the color range found by Mattila (1977). This is consistent with a major component of this diffuse intergalactic light originating as stars tidally stripped from numerous faint, low-mass dE galaxies in the cluster core.

2 Preliminary Aspects of our dE Spectroscopy

The Keck I telescope and the Low-Resolution Imaging Spectrograph (LRIS) were used in $\simeq 1.0$ arcsec seeing to obtain $2 \times 1800$ sec exposures of four fields, with $\simeq 22$ objects per field. The target objects were selected from the photometric sample described above, based upon their position within the CMD, with the additional constraint of slit placement. Our wavelength coverage is $3800 < \lambda < 6200$ Å, with 8 Å resolution and S/N $\simeq 50$ for the dEs. We have preliminary results from an LRIS field located $\simeq 3.8$ arcmin west of NGC 4874. Of the 24 objects covered with slits, 17 were “targets” (with $15.5 < R < 20.5$ mag and with $0.7 < (B - R) < 1.9$ mag), the others chosen to fill remaining slitlets. Based upon the number density of control-field objects in this region of the CMD, we would expect $\simeq 9 - 10$ of these targets to be genuine Coma members. However, only four of these targets have Coma velocities; a large fraction of the other targets are emission-line galaxies at $z \simeq 0.2$. If this unexpectedly-low fraction of Coma members is not a result of small number statistics, and if it continues to the other three LRIS fields, it will constraint measurements of the Coma luminosity function which rely
on correction using associated control fields (Bernstein et al. 1995; Secker & Harris 1996). Refer to Adami et al. (1997) for preliminary results of velocities for objects in the Bernstein et al. (1995) field. Using the dE spectra, our primary goals are to estimate age and abundances by measuring Lick spectral line indices (Worthey 1994), and to address the following questions:

(a) What is the mean metallicity-luminosity relation determined from metallicity-sensitive indices (e.g., Fe4668, Fe5709, and Fe5782); are the high metallicities inferred by integrated colors confirmed by spectroscopy?

(b) Is there evidence from age-sensitive indices (e.g., G4300, Hβ and the higher-order Balmer lines) that the dEs are composed of a homogeneous population of old stars as in globular clusters, or is there evidence for young and/or intermediate age components (as was found in some Fornax dEs; Held & Mould 1994)?

Acknowledgements

The W.M. Keck Observatory is operated as a scientific partnership between the California Institute of Technology, the University of California, and NASA. It was made possible by the generous financial support of the W.M. Keck Foundation.

References

1. Adami, C., Mazure, A., Durret, F., Lobo, C., Holden, & Nichol, R. in this proceedings (and astro-ph/9708214) (1997)
2. Bernstein, G.M, Nichol, R.C., Tyson, J.A., Ulmer, M.P. & Wittman, D., AJ 110, 1507 (1995)
3. Cellone, S.A., Forte, J.C. & Geisler, D. ApJS 93, 397 (1994)
4. Geisler, D. & Forte, J.C., ApJ 350, L5 (1990)
5. Harris, W.E., AJ 112, 1487 (1996)
6. Held, E. & Mould, J.R., AJ 107, 1307 (1994)
7. Lobo, C., Biviano, A., Durret, F., Gerbal, D., Le Fèvre, O., Mazure, A. & Slezak, E., A&A 317, 385 (1997)
8. Mattila, K., A&A 60, 425 (1977)
9. Secker, J. & Harris, W.E., ApJ 469, 623 (1996)
10. Secker, J. & Harris, W.E., Paper I, submitted to PASP (1997)
11. Secker, J., Harris, W.E. & Plummer, J.D., Paper II, submitted to PASP (1997)
12. Thompson, L.A. & Gregory, S.A., AJ 106, 2197 (1993)
13. Worthey, G., ApJS 95, 107 (1994)