# The Dwarf Galaxy Content of Hickson Compact Groups

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**Abstract**

We present deep wide field ($0.^{\circ}54 \times 0.^{\circ}54$), broad band CCD mosaic data of Hickson Compact Groups (HCGs) observed with the WFI on the ESO/MPIA 2.2 m telescope. In the past such groups were believed to lack faint galaxies, but recently a number of dwarf galaxies were found in the very cores of some groups. The outer regions of Hickson Compact Groups are largely unstudied up to now. In one of our fields (centered on HCG 16) we find for example a minimum number of 29 additional group members. We explore the distribution, structural, and color properties of dwarf galaxies in a sample of Hickson Compact Groups.

## 1 Introduction

Compact groups of galaxies are collections of 3 to 5 spiral or elliptical galaxies with small projected separations (Hickson 1997). The density of galaxies in these groups approaches or exceeds that found in rich galaxy clusters. The catalogs of group members of de Carvalho et al. (1994) are complete only down to $M_B = -16$ mag for the 13 nearest Hickson groups. This level only reaches the brightest end of the dwarf galaxy range. Hunsberger et al. (1998) used CCD images to obtain luminosity functions of compact groups down to $M_R = -14$ mag. However their field of view is limited to $13' \times 13'$ and they only have data in the R band.
In order to establish the dwarf galaxy content of such groups, especially in the outer regions, deep wide field data are necessary. Our mosaic data with a surface brightness limit of about 27 mag arcsec$^{-2}$ in B and a pixel size of $0.233''$ reveal a number of dwarf galaxy candidates of the compact groups.

Here we concentrate on HCG 16 (Figure 1) as an example of our current Hickson Compact Group sample (HCG 16, HCG 19, HCG 30, HCG 31, HCG 42).

## 2 Mosaic–Images

HCG16 (Figure 1) was observed in Johnson–Cousins B and R band using the WFI at the ESO/MPIA 2.2 m telescope at La Silla. The images have a size of $0.^{\circ}54 \times 0.^{\circ}54$. Compared to the magnitude limits of de Carvalho et al. (1994) ($M_B = -16$ mag) and Hunsberger et al. (1998) ($M_R = -14$ mag) the sensitivity of our data goes down to $M_R \approx -13$ mag.

The data were reduced using the IRAF mosaic reduction package. The object detection and extraction was done with SExtractor (Bertin 1996), which we optimized to find objects larger than

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the physical size of the smallest local group galaxy (570 pc) (Mateo, 1998). With these selection criteria we found 340 candidates. This sample includes all candidates identified by de Carvalho et al. (1997). From their radial velocities alone (de Carvalho et al.,1997), at least four of them belong to the group and 14 can be excluded.
The center of each image in Figure 2 shows one dwarf galaxy candidate of our sample. We find the LSB–galaxy ($\alpha_{2000}$ = 02 : 10 : 13.01, $\delta_{2000}$ = −10 : 04 : 34.6) of image 2a at a distance of 168 kpc from the center of the compact group. The HSB–galaxy ($\alpha_{2000}$ = 02 : 08 : 36.81, $\delta_{2000}$ = −09 : 56 : 11.4) in image 2b with a distance of 282 kpc from the center was identified as a group member by de Carvalho et al. (1997). The LSB–candidate ($\alpha_{2000}$ = 02 : 09 : 26.11, $\delta_{2000}$ = −10 : 07 : 07.1) in image 2c has a distance of 35 kpc from the center.

Except for the 18 galaxies identified by de Carvalho et al. (1997), no radial velocities exist for the remaining 322 candidates. In order to determine their group membership one could take the surface brightness as a selection criterion, but as we see in Figure 2b, there are HSB–galaxies in the sample, which were clearly identified as members by their radial velocity. A more effective selection criterion for group membership is definitively needed.

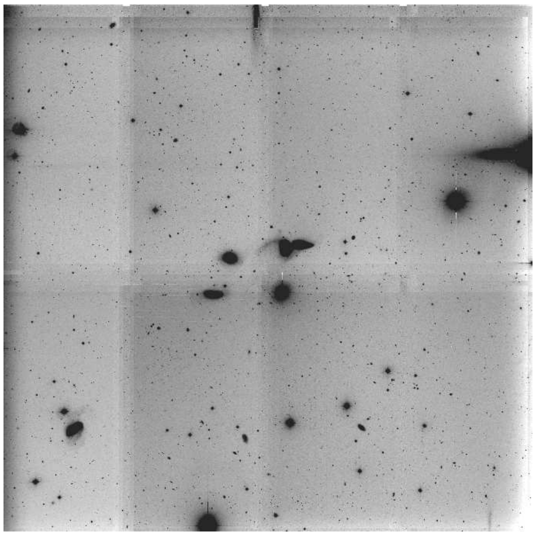

Figure 1: *Mosaic image of HCG 16 ($\alpha_{2000}$ = 02 : 09 : 31.737, $\delta_{2000}$ = −10 : 09 : 00.45) in the B band.*

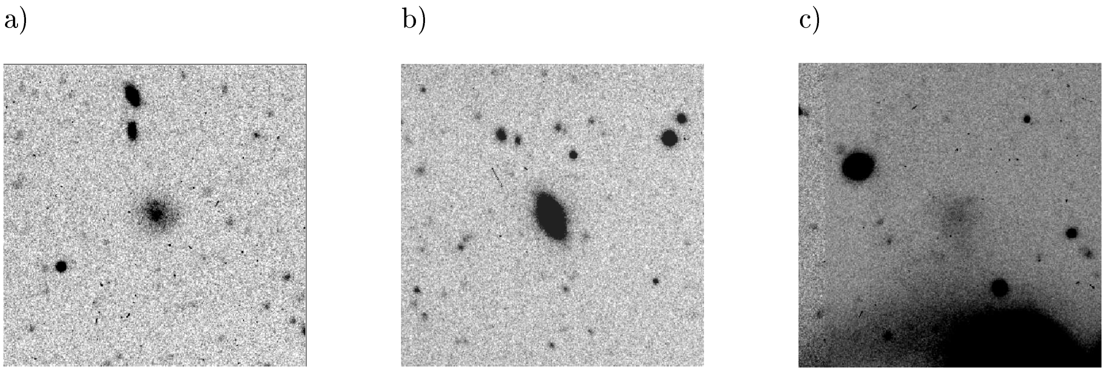

Figure 2: *Three dwarf galaxy candidates of HCG 16. The images have a size of* $400 \times 400$ *pixel* ($24 \times 24$ kpc).

## 3 Color Magnitude Diagram

With the help of a color magnitude diagram (CMD) we hope to find a more effective selection criterion for group membership for the candidates. The CMD of galaxies found in the $0.^\circ 54 \times 0.^\circ 54$ field around HCG 16 is shown in Figure 3.

Secker & Harris (1997) derived CMDs of dwarf galaxies in the Coma cluster, one of the richest Abell clusters, by concentrating on dwarf Elliptical galaxies. Dwarf Elliptical (dE) and nucleated dwarf elliptical (dE, N) galaxies are most numerous in the center of all rich clusters (Dressler, 1980; Ferguson & Sandage, 1991; Ferguson & Binggeli, 1994, Secker & Harris 1996). Secker & Harris (1997) plotted the CMDs for objects measured on three fields (centered on NGC 4874, NGC 4889, NGC 4874 south) and on a control field, which is located 2 degrees east of the cluster center at NGC 4874. They found dwarf galaxies to be obvious as an excess of objects on the three cluster fields above and over the objects of a control field. The dE galaxies are limited to a defined sequence of objects restricted to $0.7 \leq (B-R) \leq 1.9$ mag, which is completely absent from the CMD of the control field.

With the help of $(B-R)$ color index the metallicity can be estimated for the old stellar population (Geisler & Forte, 1990; Couture et al., 1991; Held & Mould, 1994; Secker, 1996) and thus the interpretation of the CMD is possible.

Compared to the CMD of dwarf galaxies in the Coma Cluster we find no clear dwarf spheroidal population in HCG 16 apart from a light indication at a color index of $(B-R) = 1.3$ mag between $R = 16$ mag and $R = 19$ mag without a clear color gradient. The much inferior definition of the sequence may be the effect of small number statistics, while the missing tilt can be attributed to slower metal enrichment in the compact group compared to a large galaxy cluster. Still, the selection of dwarf members of the group is not secure enough to draw far reaching conclusions here.

## 4 Density Distribution

Using the density distribution it is possible to predict a statistical number of candidates belonging to the group. The azimuthally averaged density distribution (Figure 4) shows a density–peak between a distance of about 30 kpc and 116 kpc from the center of the compact group by an assumed distance of $D = 53\,\mathrm{Mpc}$ based on the mean redshift (Hickson et al., 1989 and $H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$). The fact, that the peak starts from 30 kpc is not astonishing due to two reasons. First, it is possible that a few dwarf galaxies could not be identified within 30 kpc because of the bright galaxies in the center and second dwarf galaxies might have disappeared by merging with the large galaxies, which are crowding the center of the compact group. Towards higher radial distance the density distribution decreases slowly to the area limit ($r \approx 240\,\mathrm{kpc}$). Under the assumption of a nearly constant distribution of background galaxies we count a statistically number of about 29 dwarf galaxies as group members. This fits very well to the results of Zabludoff and Mulchaey (1998a, 1998b), who studied some HCGs concerning their group membership and identified spectroscopically as members 35 galaxies in HCG 42 and 63 in HCG 62.

The fact that de Carvalho et al. (1997) revealed the S shaped barred galaxy NGC 848 as a group member (at a distance of 230 kpc from the center) points at a much larger extension of the group than assumed before. This shifting of the center of HCG 16 indicates an additional uncertainty concerning the density distribution and thus creates the interpretation more difficult. This could for example mean that the peak of the density distribution is shifted in reality and furthermore we do not count all dwarf galaxy candidates because NGC 848 is situated at the edge of our mosaic image and therefore the galaxies of the area we determined as background area, might belong in reality to the group. On this evidence the statistically calculated number of group members (29) might be a lower limit.

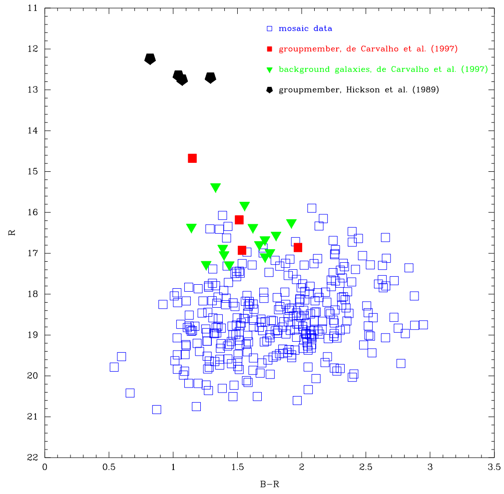


Figure 3: *CMD of dwarf galaxies in HCG 16 separated for knowledge about membership by symbol color. All symbols despite the four filled pentagons represent the 340 dwarf candidates. Four of them (filled squares) were identified as group members and 14 (filled triangles) can be excluded by their radial velocity (de Carvalho et al., 1997)*

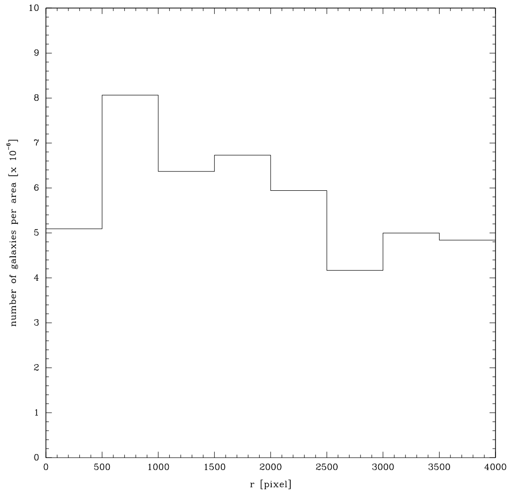


Figure 4: *Density Distribution in HCG 16 (500 pixel correspond to 30 kpc)*

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