CCD SURFACE PHOTOMETRY OF NEARBY ACTIVE GALAXIES

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1. Introduction

Up to date, only a reduced number of studies have been devoted to compare the structural properties of the host galaxy with those of normal galaxies of similar properties. Nevertheless, bars and interactions have been proposed as mechanisms to carry fuelling material to the central engine, a need shared by all AGN models. Therefore, it seems clear that a detailed knowledge of the structural parameters of active galaxies would contribute to our understanding of the nature and mechanisms of the various degrees of nuclear activity.

2. Observations

The CCD observations were performed in two runs (1988 and 1990) using the Jacobus Kapteyn Telescope (JKT) at La Palma Observatory. Broad-band VRI and narrow-band H_α interference filters were used. Our sample comprises 27 galaxies and was selected in such a way that it included a wide range of morphological types (spirals, lenticulars, ellipticals, irregulars) and all degree of nuclear activity (7 Seyfert 1, 8 Seyfert 2, 6 LINERs, 3 starbursts and 3 normal galaxies). Nearby objects were chosen in order to have a good spatial resolution (typically, that of the NLR scale size) with our instrumental configuration and expected seeing conditions. A detailed

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description of the sample, data reduction techniques used and the analysis performed can be found in Sánchez-Portal et al. (1998,1999).

3. Morphological characteristics

We have revised the morphological types of the sample objects given by de Vaucouleurs et al. (1991) (RC3). The highest abundance corresponds to early-type spirals. A fraction of 20% of the objects is composed by lenticular galaxies. A slight tendence for Seyfert 2 nuclei to inhabit galaxies of later morphological type than Seyfert 1 ones can be guessed from our sample data. We have searched for bars in the sample galaxies using several criteria (inspection of the images, ellipticity and position angle profiles analysis), and found that bars are present in a high fraction[1] of the objects with any kind of activity (i.e. excluding normal galaxies), about 71%. This proportion is even higher, about 78%, if only Seyfert galaxies are considered. These fractions are higher than those found in other samples (e.g. Xanthopoulos, 1996). These results could reinforce the clues about the connection between bars and nuclear activity. Nevertheless, there is not universal agreement on this subject (see for instance, Mulchaey & Regan, 1997).

We have studied interactions in the sample galaxies using two criteria: presence of near neighbours and morphological peculiarities. We define an Interaction Activity Class (IAC), following Dahari (1985) as an integer ranging from 1 (isolated symmetrical galaxies) to 6 (strongly disturbed or overlapped systems). We find that Seyfert 1 galaxies have a mean IAC = 2.57, higher than Seyfert 2 (IAC = 1.87) and LINERs; the latter have the same IAC than normal galaxies (IAC = 1.67). No Seyfert, LINER or normal galaxy is observed in the highest interaction class. On the other hand, our sample starburst galaxies seem to be very disturbed objects, with a mean IAC = 4.67

4. Structural parameters

We have computed bulge parameters (r_e, μ_e) and disk parameters (r_0, μ_0) by means of an iterative fitting method (Kormendy, 1977). The bulge to disk (B/D) relationship[2] has been also computed. Figure 1 shows the relationship between I band bulge (left panel) and disk (right panel) parameters for our sample objets. We have also included results from Mediavilla et al. (1989) and Xanthopoulos for comparison. We have observed a linear correlation between bulge parameters $\log r_e$ and μ_e that is also observed between

[1]For instance, in the Shapley-Ames catalog (Sandage and Tammann, 1981) 26% of all spiral galaxies and 36% of Sa0-Sbc galaxies are barred

[2]Defined as the ratio of integrated luminosity of bulge to disk

disk parameters $\log r_0$ and μ_0 that can be explained as a luminosity selection effect. On the other hand, we did not find any correlation between disk and bulge parameters and nuclear activity. Nevertheless, we observed that the mean effective surface luminosities of Seyferts are higher than in other nuclear types, being the highest that of Seyferts 1. No correlation between the B/D relationship value distribution and the nuclear type is observed.

We have found that three out of the fifteen Seyfert galaxies seem to present type II disks (according to Freeman, 1970) that could be due to the presence of an additional component, like a lens, or to a real deficience of disk material towards the center (maybe a result of the fuelling mechanism). We did not find type II disks in other nuclear types.

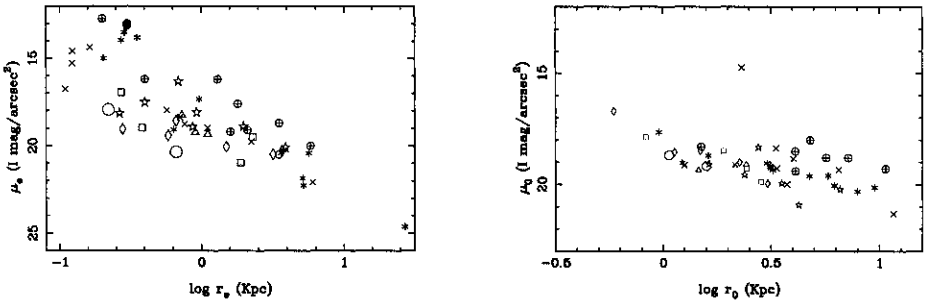

Figure 1. Relationship between I band bulge (left) and disk (right) parameteres for the sample galaxies: Seyfert 1 ($\star$), Seyfert 2 ($\Box$), LINER ($\diamond$), Starburst ($\circ$) and normal galaxies ($\triangle$). The Seyfert 1 ($*$) and Seyfert 2 ($\times$) galaxies from Xanthopoulos (1996) and the Seyfert 1 ($\oplus$) and Seyfert 2 ($\odot$) from Mediavilla *et al.* (1989) are also included

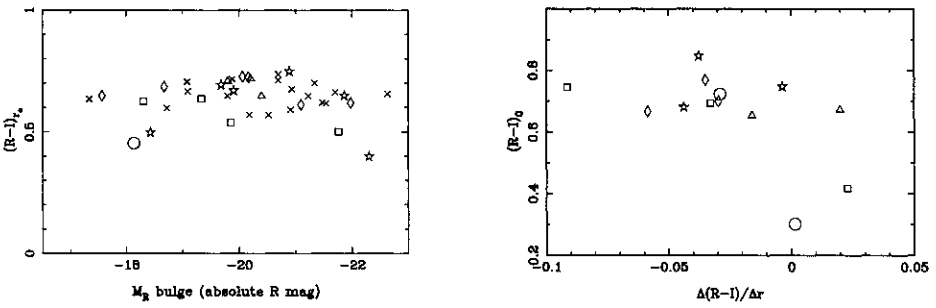

Figure 2. Left: Relationship between characteristic bulge colours and absolute R band magnitude: Seyfert 1 ($\star$), Seyfert 2 ($\Box$), LINER ($\diamond$), Starburst ($\circ$) and normal galaxies ($\triangle$). We have also included normal galaxies ($\times$) from Balcells & Peletier (1994) for comparison. Right: $R-I$ colour gradients. Symbols as above.

We have tried to characterize the bulge and disk colours of the sample galaxies avoiding the line emission contamination. We define the "characteristic" bulge colour as that measured at r_e, and the disk colour gradient

computed as the slope of a linear fit of colour vs. radial distance. Figure 2 (left panel) shows the $R-I$ characteristic bulge colour for our sample galaxies, along with comparison data from Balcells & Peletier. It can be seen that the characteristic colours are uniformly distributed in all nuclear types and are similar to those of normal galaxies[3]. This information suggests that the ages and/or metallicites of our sample bulges are similar to those of normal galaxies. On the other hand, the reduced amount of reliable disk colour gradient data (figure 2, right panel) precludes the possibility of a detailed analysis. Only a trend of Seyfert 1 central colours to be redder than those of other nuclear types can be guessed from our sample data.

5. Conclusions

The results from our morphological and structural analysis suggest that there is not correlation between nuclear activity and main structural properties (bulge and disk parameters), but with the existence of gravitational perturbations like bars and interactions. On the other hand, the characteristic colours of the host galaxies are similar in all nuclear types, and comparable with those of normal galaxies of similar morphological type.

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[3]only one Seyfert 1 galaxy with a very compact bulge shows a bluer characteristic colour, but it is contaminated by H_α emission from the NLR