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AGN POPULATION IN COMPACT GROUPS GALAXIES

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RESUMEN

El propósito de este trabajo es establecer la frecuencia de actividad nuclear (ya sea por formación estelar ó por actividad tipo AGN) en las galaxias pertenecientes a los Grupos Compactos de Hickson (CGs), y caracterizar el tipo de actividad como función de las propiedades de la galaxia huésped y del grupo que las contiene. Con este propósito, hemos seleccionado una muestra estadísticamente significativa de 65 grupos compactos del catálogo de Hickson y obtenido espectroscopía de resolución intermedia para 200 galaxias de la muestra, y tenemos datos completamente reducidos y analizados de 167 galaxias. Añadiendo a la muestra 71 galaxias observadas por Coziol et al. (1998, 2000, 2004) obtenemos una muestra de 238 galaxias. De éstas, 153 (64%) muestran emisiones y 76% posiblemente albergan un AGN.

ABSTRACT

The aim of this study is to establish the frequency of nuclear activity (AGN and star formation) in galaxies belonging to Compact Groups (CGs) and to characterize the type of activity as a function of the properties of both host galaxies and their parent group. To do so, we have selected a statistically complete sample of 65 groups from the Hickson's Catalogue of CGs and obtained medium resolution spectroscopy for 200 galaxies, from which 167 have been now reduced and analyzed. Adding 71 galaxies previously observed by Coziol et al. (1998, 2000, 2004) we obtain a sample of 238 galaxies. Of these, 153 (64%) show emissions and 76% possibly host an AGN.

Key Words: galaxies: active — galaxies: clusters: general — galaxies: statistics

1. INTRODUCTION

Compact Groups (CGs) are small associations of galaxies in close proximity to one another. Typically, the separations between galaxies are comparable with the sizes of the galaxies themselves. In many cases the galaxies in CGs show signs of tidal distortion and other phenomena induced by gravitational interactions. However, the small number of galaxies and the low abundance of inter-galactic gas observed in these systems render inefficient mechanisms like galaxy harassment or ram pressure stripping. Also, although CGs have high galaxy density ($\approx$ 1000 Mpc^{-1}), they are usually located in low density environments and have consequently low velocity dispersions ($\approx$ 200–300 km s^{-1}). These properties make CGs ideal laboratories to study the influence of galaxy-galaxy interactions, or galaxy-group interactions, on morphological evolution and the possible triggering of nuclear activity.

In CGs, tidal interaction is expected to result in an efficient mechanism to transport material to the very center of the galaxies, feeding an AGN and/or increasing star forming activity. It implies that the proportions of nuclear active galaxies is expected to be higher than observed in the field. To verify this hypothesis, we have initiated a systematic survey to determine the nature of activity found in a well defined sample of CGs.

2. THE SAMPLE

Starting with the list of 92 groups with concordant redshift galaxies in the Hickson's Catalogue of CGs (1982), we have selected all the groups with $\mu <$ 24.4 mag arcsec^{-2} and $z < 0.045$, yielding a complete sample of 65 groups formed by 283 galaxies.

For this sample we have obtained new medium resolution spectroscopy for 200 galaxies using four different telescopes: the 2.5 m NOT in El Roque de los Muchachos (RM, Spain), the 2.2 m in Calar Alto (CAHA, Spain), the 2.12 m in San Pedro Mártir (SPM, Mexico) and the 1.5 m in Sierra Nevada (OSN, Spain). Our spectra cover the spectral range from 3200 Å to 7200 Å with a spectral resolution from 4 Å using the CAFOS spectrograph (CAHA, Spain) to 8 Å using the Boller & Chivens spectrograph (SPM, Mexico).

Here we present the results from 167 of these galaxies. Adding to this first sample the spectroscopic data obtained by Coziol et al. (1998, 2000,

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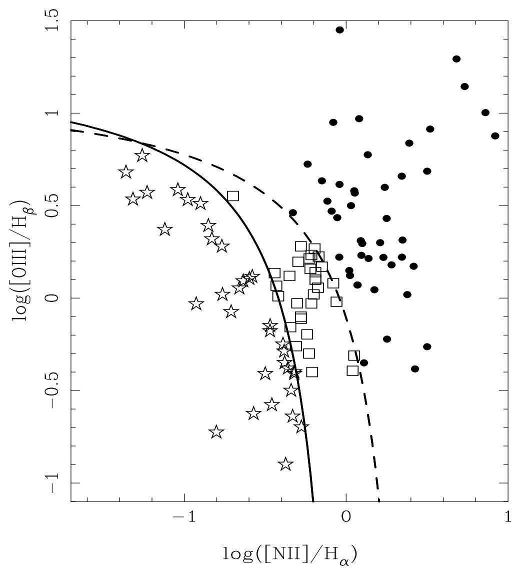

Fig. 1. BPT diagram with the two sequences used for nuclear classification. The solid line corresponds to Ka03 separation while the dashed line corresponds to the Ke01 sequence (as explained in the text). Stars correspond to SFNGs, filled circle to AGN and open squares to TOs.

2004), we have a total of 238 galaxies in 61 groups from which nuclear activity can be determined.

The classification of nuclear activity was done using Baldwin et al. (1991, hereafter BPT) optical diagnostic diagram, that involves log([OIII]5007 Å/H_β) versus log([NII]6584 Å)/H_α). Following Stasińska et al.(2006) method, we have not imposed any restriction on the S/N ratio, which would have artificially reduced the number of AGN in our sample.

In the cases where the main four emission lines were detected, we used the BPT diagram (Figure 1) and two sequences to discriminate between Star Forming Nuclear Galaxies (SFNGs) and AGN: (1) Galaxies that lie above the sequence of Kewley et al. (2001, hereafter Ke01) were classified as pure AGN; (2) galaxies located below the sequence of Kauffmann et al. (2003, hereafter Ka03) were classified as SFNGs. Galaxies that lie between these two sequences were classified as Transition Objects (TOs). The spectra of these galaxies can be explained assuming AGN activity is diluted by circumnuclear star formation.

The classification of galaxies where only two lines (Hα, [NII]) are detected was done following Stasińka et al. (2006) criteria: the galaxy was classified as an AGN when log([NII]/Hα)> -0.1, as a SFNG when log([NII]/Hα)< -0.4 and as a TO galaxy otherwise.

TABLE 1

GALAXY PROPERTIES

Activity	Morphology	cz (km s^{-1})	M_B (mag)
Non Em.	−2.1(S0)	8730	−20.1
AGN	0.9(Sa)	8183	−20.4
TO	2.5(Sb)	7562	−20.6
SFNG	4.75(Sbc)	6177	−19.4

Galaxies with only the [NII]6584 line detected have been classified as AGN. These cases can be explained assuming faint emission coming from the nucleus is diluted by absorption features produced by numerous intermediate aged stars. Coziol et al. (1998, 2000) have shown that galaxies with this spectroscopic characteristic are consistent with Low Luminosity AGN and are very frequent in CGs.

The nuclear classification of the 153 emission line galaxies in our sample yields the following results: 37 (24%) SFNGs, 72 (47%) pure AGN and 44 (29%) TOs. Adding AGN and TO together (AGN+TO) suggests that 76% of the emission lines galaxies in our sample could host an AGN. In general, AGN represent 49% of all the galaxies in our sample, followed by 36% non-emission galaxies and 15% SFNGs. AGN, consequently, formed the dominant activity type.

3. ACTIVITY, GALAXIES AND PARENT GROUP PROPERTIES

The relation between the presence of nuclear activity and the properties of the host galaxy and of their parent group is explored in Figure 2 and Table 1. In Figure 2a, we find that non-emission line nuclei are hosted in earlier morphological types (typically S0) than emission line galaxies. Focusing on the later, we see that AGN are hosted in earlier types than TOs or SFNGs. The median morphology is Sa for AGN, Sb for TOs and Sbc for SFNGs. This agrees with other results obtained in the field or in groups (Moles et al. 1995; Coziol et al. 1998, 2000; Martínez et al., in prep.; del Olmo et al. 2008). Therefore, in general, AGN have earlier morphological types than SFNGs. This trait is not typical of CGs, but of AGN. What is new here, however, is the tendency for TOs to also be intermediate in terms of morphology, between AGN and SFNG, which seems consistent with our interpretation for this activity type.

Concerning the absolute magnitude of the host galaxies, we find in Figure 2b and Table 1 that the TO galaxies are among the brightest, while the SFNGs are among the faintest galaxies.

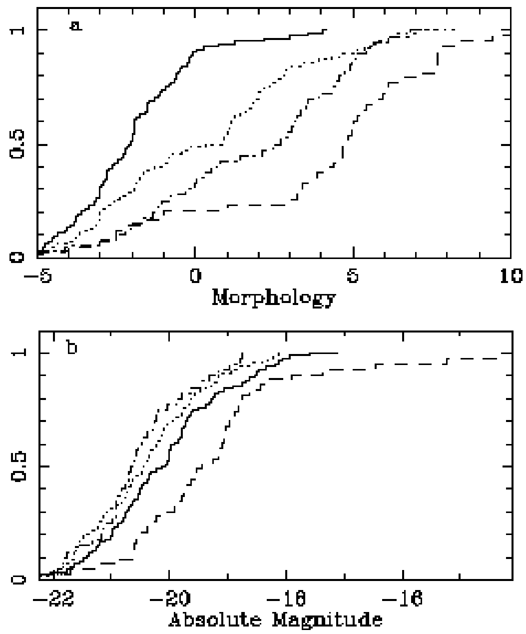

Fig. 2. Cumulative distribution functions of the morphology, and absolute magnitude in B band of the host galaxy for each nuclear type. The solid lines correspond to non-emission galaxies, the dotted lines to AGN, the dashed lines to SFNGs and dashed-dotted lines to TOs.

According to our analysis we conclude that pure AGN in CGs are located in bright early type galaxies, usually early spirals, while SFNGs are hosted in fainter and later spiral types. TOs, on the other hand, are located in later morphological types than AGN, but with higher luminosity than SFNGs.

We have also checked if groups dominated by different activity types have different properties (group velocity dispersion, σ_v, and mean pairwise separations, R_p). By dominant activity, we mean that more than half of the galaxies in the group bare this type. Our analysis is complete for 53 of the 61 groups. We count 8 groups dominated by non-emission line galaxies, 4 groups dominated by SFNGs and 22 by AGN and/or TOs. The remaining 19 groups show a mixture of types.

As can be seen in Table 2, groups dominated by non-emission line galaxies have high velocity dispersions. One can see also that AGN+TO dominated groups have higher velocity dispersions than SFNG dominated groups. We find also that AGN+TO and non-emission line dominated groups have similar size while SFNG dominated groups are smaller.

TABLE 2

GROUP PROPERTIES

Dominated by	σ_v (km s^{-1})	R_p (kpc)	cz(km s^{-1})
Non Em.	276	37	7260
AGN+TO	176	42	8100
SFNG	73	10	4725

4. SUMMARY AND CONCLUSIONS

Summing up our analysis, we found the following:

- Of the 238 galaxies in our sample, 64% (153) have emission lines.
- Between 47% (pure AGN) and 76% (AGN+TO) of these galaxies host an AGN.
- AGN are in earlier and brighter morphological types than SFNGs.
- AGN+TO dominated groups have higher σ_v and R_p than SFNG dominated groups.

Taken as a whole, Hickson's CGs does not seem to favor nuclear activity, since a large fraction (36%) of the galaxies show no emission. However, the relation between activity type and morphology suggests this may be due to an evolutionary effect. The relation with σ_v points in the same direction: the more evolved systems have higher velocity dispersion (Coziol et al. 2004). This is consistent with hierarchical structures formation, assuming massive structures form before smaller mass ones.

On the other hand, if we consider the mixture of activity, our sample seem to be predominantly rich in AGN. It suggests that most Hickson's CGs are in an intermediate evolutionary phase, where tidal interactions and mergers transform spiral galaxies into earlier types (S0 and Elliptical galaxies).

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