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A new compact groups sample in the southern sky

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Abstract. Compact groups of galaxies are an extreme class of object, ideal for the study of galaxy interactions and their effects. In this paper we present a new algorithm, devised to select compact groups from digitized catalogues of galaxies and especially suited to reach fainter magnitudes. We present also the results obtained from the redshift survey of the bright subsample of such groups.

1. Introduction

Compact Groups of galaxies (CG's) represent an extreme class of objects: they typically contain 4-8 galaxies with high space densities (as in the centers of rich clusters) but with low velocity dispersions. Therefore they are excellent laboratories for the study of galaxy interactions and their effects. Up to now there was no unbiased sample of CG's available in the literature and therefore several of the classical problems and paradoxes involving CG's could not be properly addressed. We decided to exploit the availability of large digitized galaxy catalogues to develop an algorithm for compact groups detection that implements clearly defined and rigidly applied selection criteria. The new algorithm is optimized for work at fainter magnitudes, where both incompleteness and contamination become serious problems. The automated approach has the great advantage of producing a complete and homogeneous sample of compact groups, free from the biases which affect visual searches. The redshift survey of a bright subsample of the new CGs catalogue has just ended, and we present a preliminary comparison of the dynamical properties of this new automated sample with those of the Hickson compact groups sample (HCG).

2. The New Algorithm

The main problem we have addressed with the new algorithm is to reduce to a minimum contamination by chance projection groups, a problem that becomes very serious at fainter magnitudes, where the surface density of field galaxies increases drastically. According to the criteria originally devised by Hickson, an aggregation of galaxies is defined as a compact group, if it contains 4 or more galaxies in a compact configuration and isolated from the surrounding field (Hickson, 1982). The criteria are quantified by the following formulae:

- richness $n_{members} \geq 4$
- isolation $R_{isol} \geq 3R_G$
- compactness $\mu < 26$ within R_G (R band)

For all the three criteria, the galaxies to be considered are those within three magnitudes of the magnitude of the brightest group member. Going to fainter magnitudes, background galaxies can, by chance, be superimposed on the isolation ring of a foreground group, causing it to be rejected by the isolation criterion. The reverse can also happen: a faint galaxy can be projected on an existing triplet, causing it to be accepted by the richness criterion.

At brighter magnitudes, the surface density of the faintest galaxies entering the sample is so low that these two problems do not affect too much the search. Furthermore, in a visual search there are other (implicit) criteria used to select the sample, that can help to alleviate these problems; as shown by Prandoni et al. (1994), the sample selected visually at bright magnitudes by Hickson satisfy tighter constraints than those stated explicitly. However, with an automated search which reaches fainter magnitudes, these two problems can become a major source of incompleteness and contamination.

To alleviate these problems, we have changed the original Hickson's criteria, relaxing the 3 magnitude interval. Our new algorithm still asks for the richness and compactness criterion to be satisfied, *i.e.* that the group should have four or more members such that their surface brightness $\mu \leq 26$ within R_G, the radius of the group, but the isolation constraint asks that no galaxy of magnitude comparable with that of the group members is found in a circle of radius $R = 3R_G$. Therefore the group is defined by two intervals of magnitude:

$\Delta mag_{members} = (m_{faintest} - m_B)$, *i.e.* the magnitude interval between the brightest and the faintest member of the group;

$\Delta mag_{isolation}$, *i.e.* the magnitude interval between the brightest member and the brightest galaxy within the circle of radius $3R_G$,

with the two constraints:

$$\Delta mag_{members} \leq \Delta mag_{isolation},$$

$$\Delta mag_{members} \leq 3.$$

Relaxing the isolation criterion has the effect of keeping groups that could be physically bound and isolated, despite their having an interloper (physically unrelated) in the isolation ring. On the other hand, as the isolation criterion is relaxed, sub-condensations within clusters will enter the sample. To reject such objects a further constraint has to be introduced. For each group, we take into account all the galaxies within 3 magnitudes of the brightest galaxy, and calculate:

$\mu_{ext} - \mu_{int}$

i.e. the difference between the surface brightness within the group and that of the isolation ring, taking into account all the galaxies in an interval of 3 magnitudes from the brightest. If this is less than 4.0, the group is rejected. Such a limit on the luminosity contrast, corresponding to a contrast in projected mass density of $\sim$ 40, is very effective in rejecting sub-condensations within larger structures. We cross-correlated with the position of Southern Abell clusters the 50 groups with magnitude of the starting galaxy brighter than 15.0 rejected because of this constraint. More than 50% were found to be sub-condensations within known Abell clusters.

We applied the algorithm described above to an area of $\sim$ 5000 sq deg in the southern sky. The data base consisted of a catalogue of $\sim 1,000,000$ galaxies, obtained through COSMOS scans of $\sim$ 200 UKST b_j plates (MacGillivray and Stobie, 1984). As output we obtained 143 new compact groups, complete down to $b_j = 15.0$ for the magnitude of the brightest galaxy of the group, *i.e.* $\sim$ 1 magnitude fainter than the groups catalogued by Hickson. The estimated total contamination rate of the sample is $\sim$ 28%, and is determined by applying the algorithm on the same database of galaxies after shuffling it in α and δ.

3. Redshift survey of the bright subsample

Using the ESO 1.5m telescope at LaSilla, we measured redshifts for all members of 60 candidate CGs, defining a bright subsample (down to $b_j \sim 14.5$ for the brightest galaxy of the group). Assuming a velocity cut-off of $1000\,\mathrm{km\,s^{-1}}$ from the median velocity of the group, we obtain a total of 49 groups of galaxies with three or more concordant members. Being selected in an automated fashion, such a sample is ideal for statistical studies of compact groups.

In the following I will compare the dynamical properties of our new sample of concordant groups (SCGs, Southern Compact Groups) with those of the 56 groups in the original Hickson sample with starting galaxy brighter than 14.5 (hereafter BHCGs and bright HCGs respectively). As in our sample we can select the subsample of groups that strictly satisfy the Hickson criteria (*i.e.* the subset such that $\Delta mag_{isolation} = 3$, giving 27 groups), we will be able to disentangle if any difference in properties is a consequence of having changed the selection criteria or is related to the biases affecting Hickson's visual search.

Fig. 1 shows the histogram of the distribution of mean group velocity. There is no major difference between BHCGs and SCGs: any incompleteness in the HCGs sample is not simply incompleteness in magnitude of the starting galaxy, confirming the presence of subtler biases in HCGs.

Fig. 2 shows the difference in velocity amongst the group member galaxies: it is similar in BHCGs and SCGs samples, and as a consequence both the mean measured velocity dispersion of the groups and the mean deprojected 3D velocity dispersion are similar, being of the order of $200\,\mathrm{km\,s^{-1}}$ and $350\ \mathrm{km\,s^{-1}}$ respectively for both samples.

Fig. 3 shows the distribution of total group magnitudes for SCGs and BHCGs: here is visible the incompleteness of BHCGs at faint magnitudes. Such incompleteness, as Fig. 1 suggests, is not simply a consequence of having missed

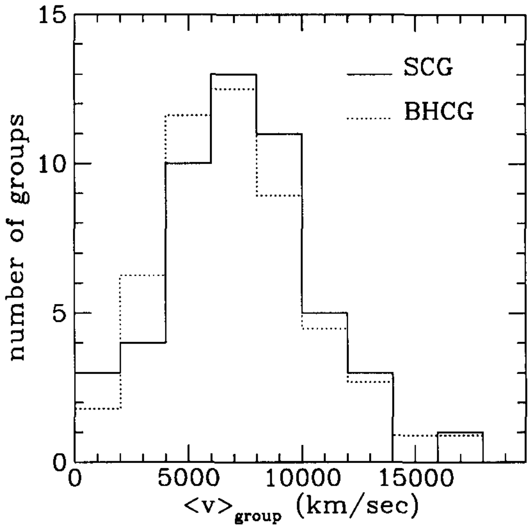

Figure 1. Distribution of the mean group velocity. Continuous line is for the SCGs sample, while the dotted line is for the BHCGs sample.

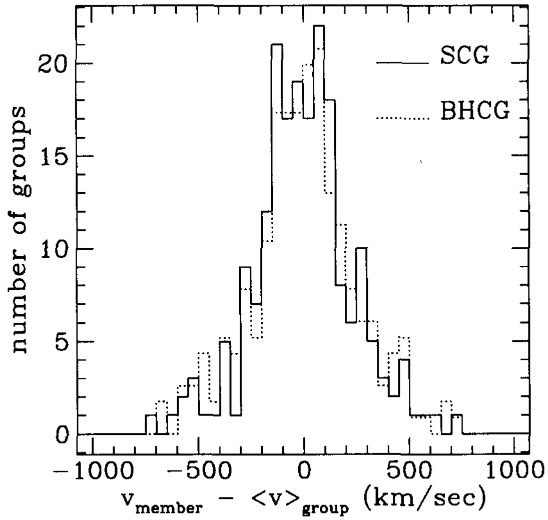

Figure 2. Distribution of galaxy velocities with respect to the median velocity of all catalogued galaxies in the same group. Continuous line is for the SCGs sample, while the dotted line is for the BHCGs sample.

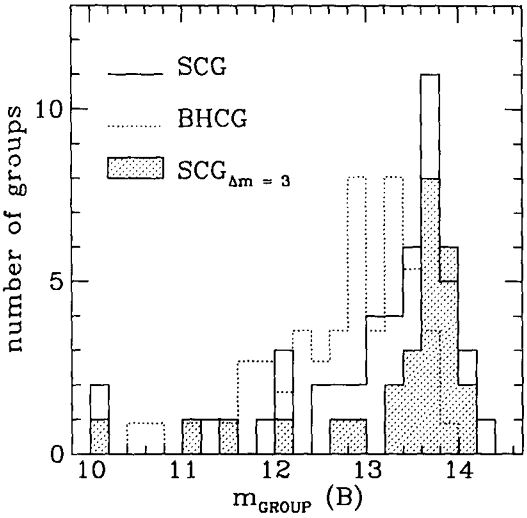

Figure 3. Distribution of total group B magnitudes for SCGs and BHCGs. The hatched histogram indicates the subset of SCGs strictly satisfying Hickson's criteria, while continuous line is for SCGs and dotted line for BHCGs.

in the visual search those groups with faint starting galaxy, but has to be retraced to subtler selection biases such as having missed *e.g.* groups whose magnitude difference between brightest and faintest galaxies is close to the 3 magnitudes cut-off. The corresponding lack of bright groups in SCGs, on the other hand, is simply due to the different sky coverage of the two surveys: SGCs miss the rare high luminosity groups due to the small area covered.

Another quantity whose distribution is different for the two samples is the group surface brightness: it was already known that the HCGs sample is biased towards objects at high surface brightness and Fig. 4 shows this effect. Also typical radii, and therefore projected radii in kpc, are larger for SGCs than for BHCGs. Direct comparison with the subset of SGCs satisfying the Hickson criteria confirms these differences are not due to the change of selection criteria. Such differences translates into a difference in typical crossing times: $< t_c H_0 >$ being 0.022 and 0.051 for BHCGs and SCGs respectively.

4. Discussion

The original sample selected by Hickson has been extremely fruitful: the very existence of such a class of objects has prompted two decades of work on the subject (the large number of papers in these proceedings dedicated to HCGs is still today clear evidence for it).

On the other hand we should not be blind to the fact that such sample is biased in subtle ways. Due to the visual search used to define HCGs, groups that are at the *border* of the selection criteria are easily lost. The groups that Hickson catalogued are the tip of the iceberg of the compact groups distribution, even when using exactly Hickson's criteria in the automated search. HCGs are most likely configurations more evolved and extreme in properties within the CGs

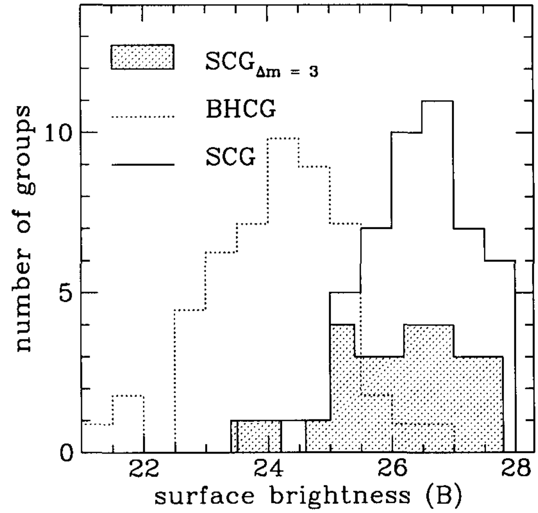

Figure 4. Distribution of groups surface brightness. The hatched histogram indicates the subset of SCGs strictly satisfying Hickson's criteria, while continuous line is for SCGs and dotted line for BHCGs.

class, and this could be a serious problem if one wants to study such objects in a statistical fashion: there is the risk of assuming that HCGs are representative of the full class of objects defined by the selection criteria, while this is not the case.

Our new automated sample, selected changing slightly Hickson's original criteria, shares all the dynamical properties the HCGs sample would have if complete, and therefore can be used to study in a systematic fashion the properties of compact groups.

References

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