Kinematics of compact groups and morphologies of the member galaxies

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Abstract

We present the results of a kinematical and morphological study of galaxies in the Hickson compact groups. The redshift survey of 457 galaxies has been completed. The great majority of the galaxies have velocities within about 1000 km s^{-1} of the median velocity of the group. The velocities of the groups range from 1380 to 41731 km s^{-1} with a median of 8889 km s^{-1}, corresponding to a median distance of 89 h^{-1} Mpc. With the addition of the radial velocity selection criterion, a relatively large sample of physically dense compact groups was defined.

The nature of the velocity dispersion–morphology relation (Hickson, Kindl and Huchra 1989, hereafter HKH) is investigated. This is the tendency of groups with high velocity dispersions to contain fewer late–type galaxies. We find that this strong correlation is not due to any sample selection effects. The morphology concordance in compact groups (HKH), which is the trend for galaxies in a group to have similar morphological types, can be fully explained by the velocity dispersion–morphology correlation.

A significant correlation is found between crossing time and the fraction of gas–rich galaxies in the groups. Groups with short crossing times typically contain fewer late–type galaxies. This may be evidence that significant dynamical evolution has occurred in these groups.

Introduction

The Hickson Compact Groups (HCGs) are a sample that consists of 100 nearby groups of galaxies which typically contain four members. These were catalogued from a visual search of the Palomar Sky Survey red prints following a few criteria of magnitude concordance, isolation and surface brightness (Hickson 1982). For a large fraction of the groups, the spatial density of galaxies is as large as that in the cores of rich clusters of galaxies.

The conventional scenario for the history and fate of these compact groups is that their members will interact and merge into one single elliptical galaxy on time–scales comparable to their orbital periods (Barnes 1989). Therefore, compact groups may be ideal environments in which to study the formation of elliptical galaxies through mergers and the effects of collisions on the evolution of galaxies.

Results

We find that more than 84% of the galaxies have velocities within 1000 km s^{-1} of the median velocity of the group (hereafter, accordant members). 92 groups have at least three accordant members, and 69 groups have at least four. The median projected radial velocity dispersion of the groups is 200 km s^{-1}, comparable to values reported for loose groups. The median projected separation between galaxies within each group is 39 h^{-1} kpc and the median galactic crossing time is 0.016 Ho^{-1}. The details of the redshift survey are described in Hickson *et al.* 1992.

We have also studied the morphology of the galaxies in HCGs, and we have investigated correlations between dynamical parameters (velocity dispersion, crossing times) and morphological and structural parameters (fraction of late–type galaxies, brightness and size of the first–ranked galaxy, luminosity contrast of the first–ranked galaxy, degree of galactic asymmetry, interaction strength, intergalactic median separation). The only significant correlation, in addition to a velocity dispersion–morphology correlation (HKH) discussed below, was a crossing time–morphology correlation. Groups with short crossing times typically contain fewer late–type galaxies. This may be evidence for dynamical induced changes in the galaxy morphologies. Model collisions of two galaxies of comparable masses generally produce remnants that resemble elliptical galaxies (Barnes, 1989 and White, 1990). The correlation of crossing time with galaxy morphology is qualitatively consistent with this picture, assuming that the probability of an interaction increases as the crossing time decreases.

HKH analyzed a subsample of 60 HCGs and found that the group spiral fraction does not correlate strongly with the median projected galaxy separation. However, a strong correlation was found between the velocity dispersion and the fraction of late–type galaxies in the groups. Groups with high velocity dispersions contain fewer late–type galaxies. We find that this correlation is not caused by any selection effects in the sample and it must be real.

The HCGs are known to follow a morphological–type concordance (HKH). For the sample of 47 groups with redshifts $z \leq 0.03$, 28% have either only late–type galaxies or only early–type galaxies. The probability of this occurring from a random mix of morphological types is less than 10^{-3}. White (1990) pointed out that the probability calculation must take into account the morphology–velocity dispersion correlation. To test if the morphology–velocity dispersion correlation could explain the morphology concordance in the groups, we simulated quartets of galaxies with velocity dispersions drawn from a Gaussian distribution which matched the observed distribution for HCGs with $z \leq 0.03$ (mean = 2.2 and dispersion = 0.3, in the log). We then selected a sample of simulated groups which followed a morphology–velocity dispersion correlation as observed ($\sigma_v = -1.71 f_s + 3.21$, where σ_v is the velocity dispersion of the group and f_s the fraction of spiral galaxies). For 10000 runs of 47 groups we find that in 23% of the cases we are able to create a morphology concordance which is as strong or stronger than the one observed. This indicates that the morphology concordance in HCGs can be explained by the existence of the strong morphology–velocity dispersion correlation for compact groups.

References

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