Galaxy Groups in the 2dF in Terms of their Degree of Compactness and Isolation

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Abstract

A computer program that searches for groups of galaxies in catalogues (2dF, LEDA, etc.) in terms of compactness and isolation parameters has been developed. The program works by listing the neighbours of each galaxy sorted by distance. Once the list is done it is straightforward to form groups according to the isolation and compactness parameters chosen. In this work we present the results for the application of this program to the 2dF. We have found that plausible numbers for the parameters roughly yield the same number of groups than those found by group searching programs such as the Friends of Friends algorithm, but that there are some differences. As a result of this work we have found that with this approach, it is possible to gain insight on the nature of galaxy groups, and to complement the interpretation of those found in other studies.

In Hickson´s original contribution in 1982, compactness and isolation were the basis for the selection criteria. He expected that by studying the HCG catalog one could find possible implications about the dynamical evolution.

a) Selection Criteria

A compact group is defined here by the following criteria:

$$N \geq 4 \quad \text{(population)}, \tag{1}$$

$$\theta_N \geq 3\theta_G \quad \text{(isolation)}, \tag{2}$$

$$\bar{\mu}_G < 26.0 \quad \text{(compactness)}, \tag{3}$$

where N is the total number of galaxies within 3 mag of the brightest, $\bar{\mu}_G$ is the total magnitude of these galaxies per arcsec^2 averaged over the smallest circle (angular diameter θ_G) that contains their geometric centers, and θ_N is the angular diameter of the largest concentric circle that contains no other (external) galaxies within this magnitude range or brighter.

We adopt a different, but in spirit somewhat similar selection criteria for the search of the groups, as those of Hickson.

The main motivation, is to obtain statistical information on the groups, with the hope that this empirical results can provide information on their evolution.

Galaxy Groups

It is well known that galaxy groups are very usefull as tracers of large scale structure.

But they should also be usefull to study the local dynamics of bound systems. This is the main goal of this work

Is it possible to measure empirically the lifetime of groups?

Is there a connection with isolated galaxies (which are so scarce)

Datos de LEDA
The columns in the galaxy data files contain:
1) RA in radians (1950 coordinates)
2) dec in radians (1950 coordinates)
3) redshift
4) b_J magnitude
5) limiting b_J magnitude of the survey at the position of this galaxy
6) the mean number density of galaxies in the survey at the position of this galaxy
7) the weight associated with this galaxy
8) the group number to which this galaxy has been assigned - 0 is ungrouped
and k refers to the kth entry in the corresponding group list.

The Group Finder Algorithm

▪Read the 2dF catalog.

(♋$_i$, ♎$_i$, z_i), (♋$_2$, ♎$_2$, z_2),…., (♋$_n$, ♎$_n$, z_n)

n=112,694 galaxies in the 2dF South

n= 78,746 galaxies in the 2dF North

Turn on all the galaxies (flag(k)=1, for k=1,2,….,n)

▪z restriction: $|z_i - z_j| < \Delta z$ (we took $\Delta z = 0.01$).

▪For galaxy i, calculate the angular distances ✈$_{ij}$ from *i* to *j*, for all *j* 🕓 *i* that satisfy the z restriction:

✈$_{ij}$ =acos[sin(♎$_i$)sin(♎$_j$)+cos(♎$_i$)cos(♎$_j$)]cos(♋$_i$-♋$_j$)

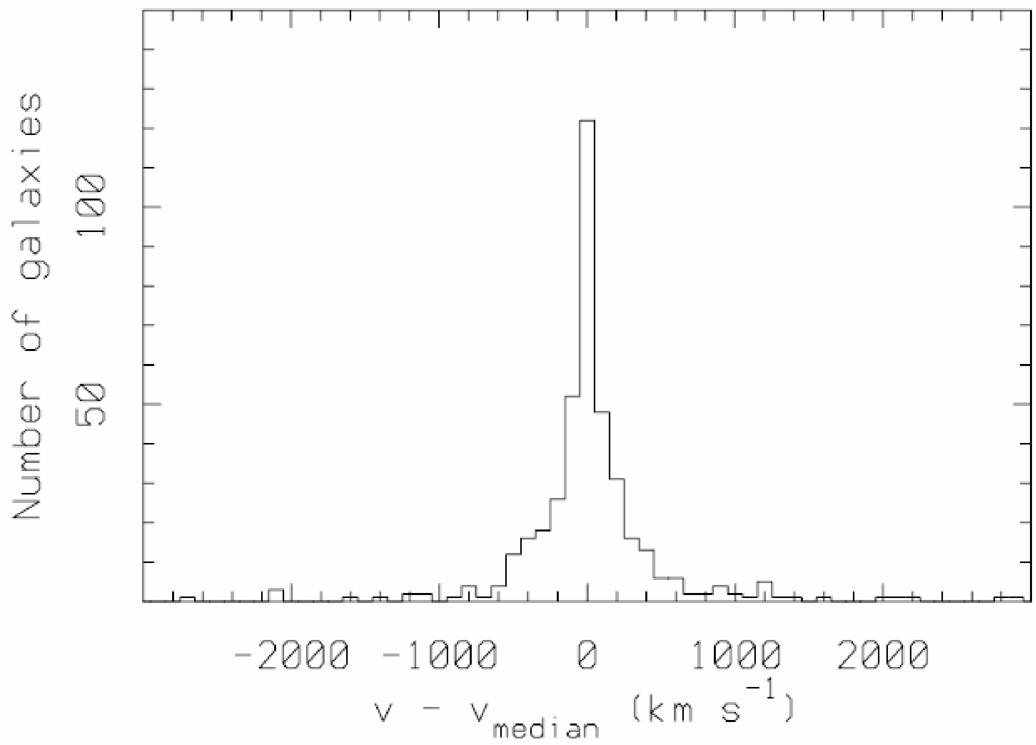


Fig. 2.— Velocity distribution of galaxies in compact groups. The figure shows the distribution of the difference between the observed galaxy radial velocity and the median velocity of galaxies in the group to which it belongs, for 410 galaxies in the HCG catalog. Most galaxies (77%) have velocity differences less than 500 km s^{-1} from the median.

Hickson, P. 1997, ARA 35

▪Calculate the projected distances $R_{ij} = r_{ij}$ ✈$_{ij}$, where r_{ij} is the distance from us to galaxy i. From Hubble´s law, $r_{ij} = 0.5(z_i – z_j)c/H_0$.

▪For each galaxy i, sort the distances R_{ij}, from the first nearest neighbor to the last. We call ***s(1)*** to the projected distance to the first nn, ***s(2)*** to the distance to the second nn, and so on.

Selection of groups

The groups are formed according to the compactness ($r_{compactness}$) and isolation ($r_{isolation}$) parameters.

A group of ***2*** galaxies is compact and isolated if it satisfies the following criteria:

s(1) ⦿ $r_{compactness}$

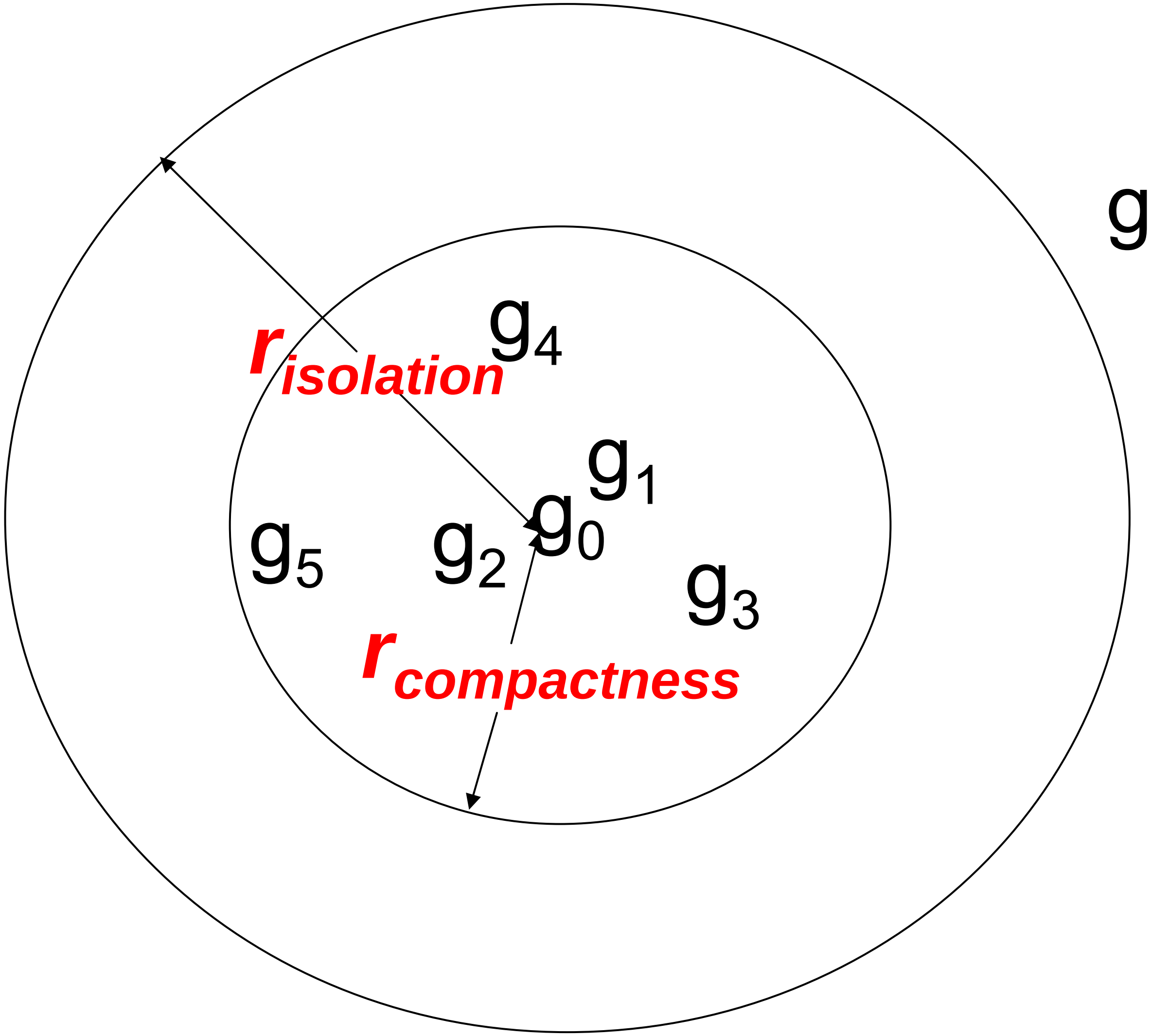
and s(2) ¤ $r_{isolation}$

Likewise, a group of ***n*** galaxies is compact and isolated if it satisfies the following criteria:

$$s(n-1) \odot \boldsymbol{r}_{\boldsymbol{compactness}}$$

and $$s(n) \text{ ¤ } \boldsymbol{r}_{\boldsymbol{isolation}}$$

Isolated Compact Group of 6 galaxies



Notice that the space between $r_{compactness}$ and $r_{isolated}$ is devoid of galaxies.

If a compact group is found for galaxy i, flag(j) are set to 0, for its companions. If the group is not found, the flags remain equal to 1. In this way, the groups that are found have no intersection (i.e. no common galaxies).

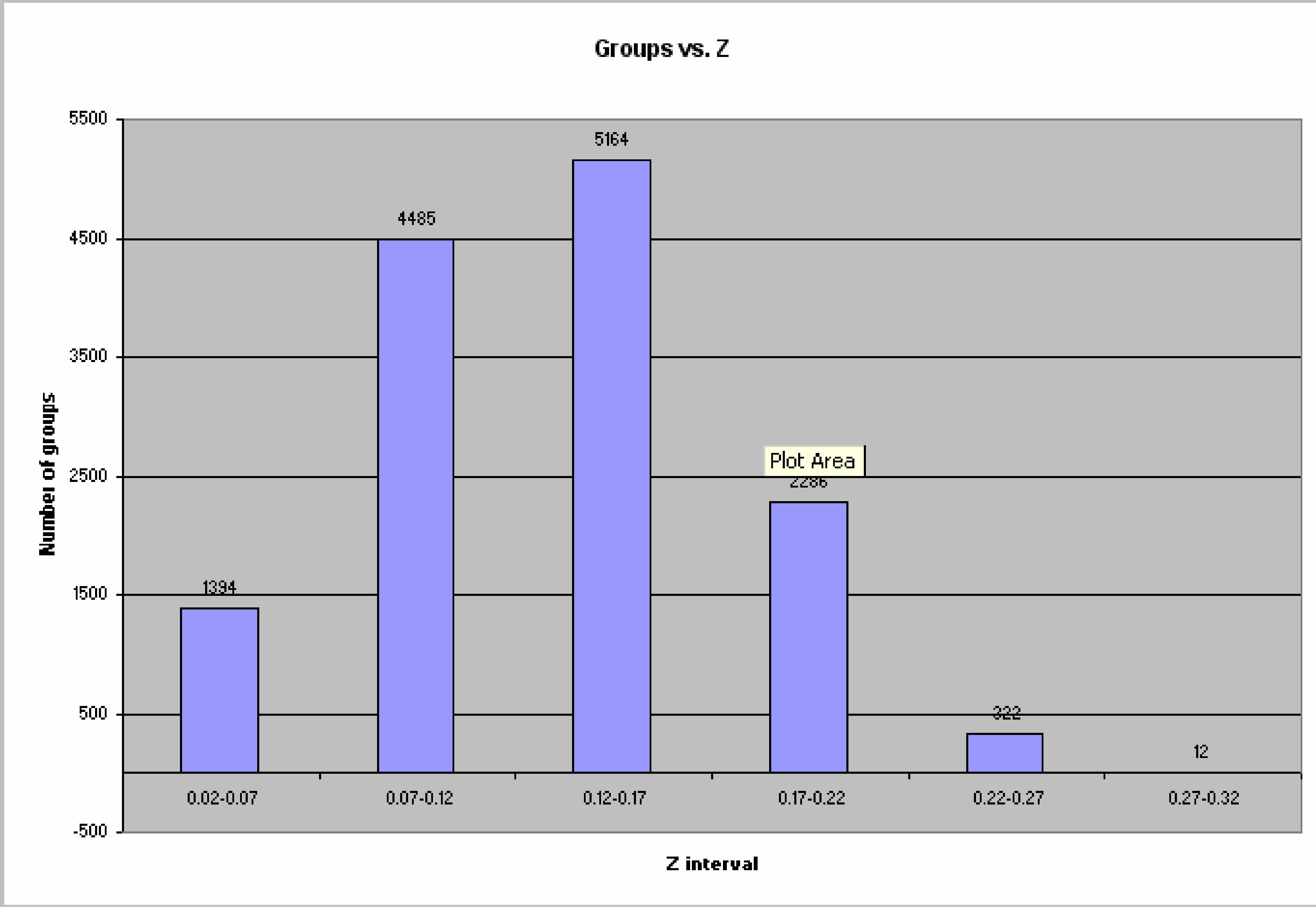
Results

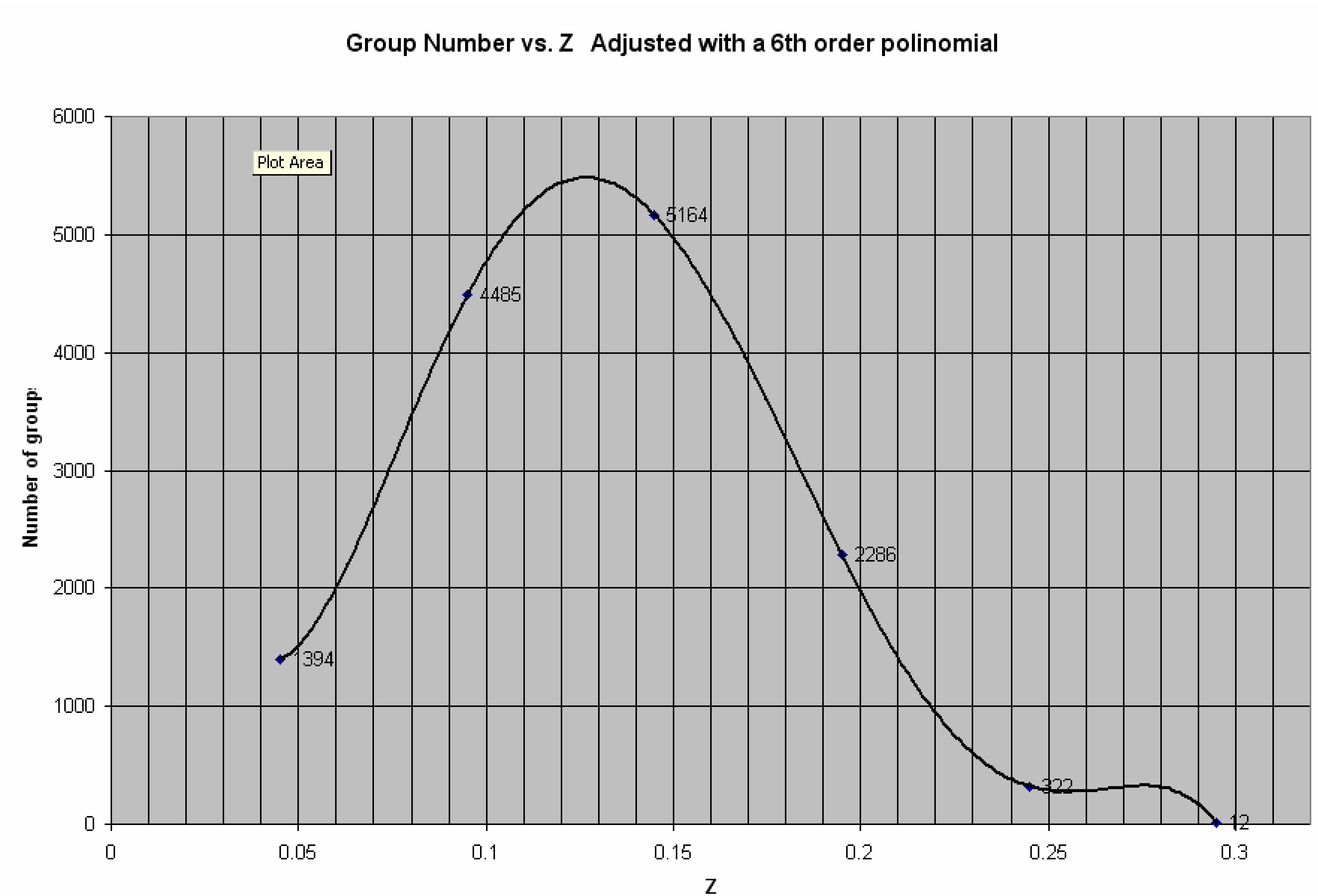
We run the program, sampling the 2 parameter space, trying to find statistical properties of the groups that are found.

Groups found (N+S) in the 2dF for $r_{isolation}$ =2.0 Mpc. Blue: Eke et al 2004; red: this work

r_{comp} □	1.60	1.61	1.62	1.63	1.64	1.83
Total # groups				23986	24202 28877	28877 28877
⌑3 gal				12564 12556	12729	
⌑4 gal	6934	7082 7020				
⌑5 gal		4419	4520 4503			

Degen.

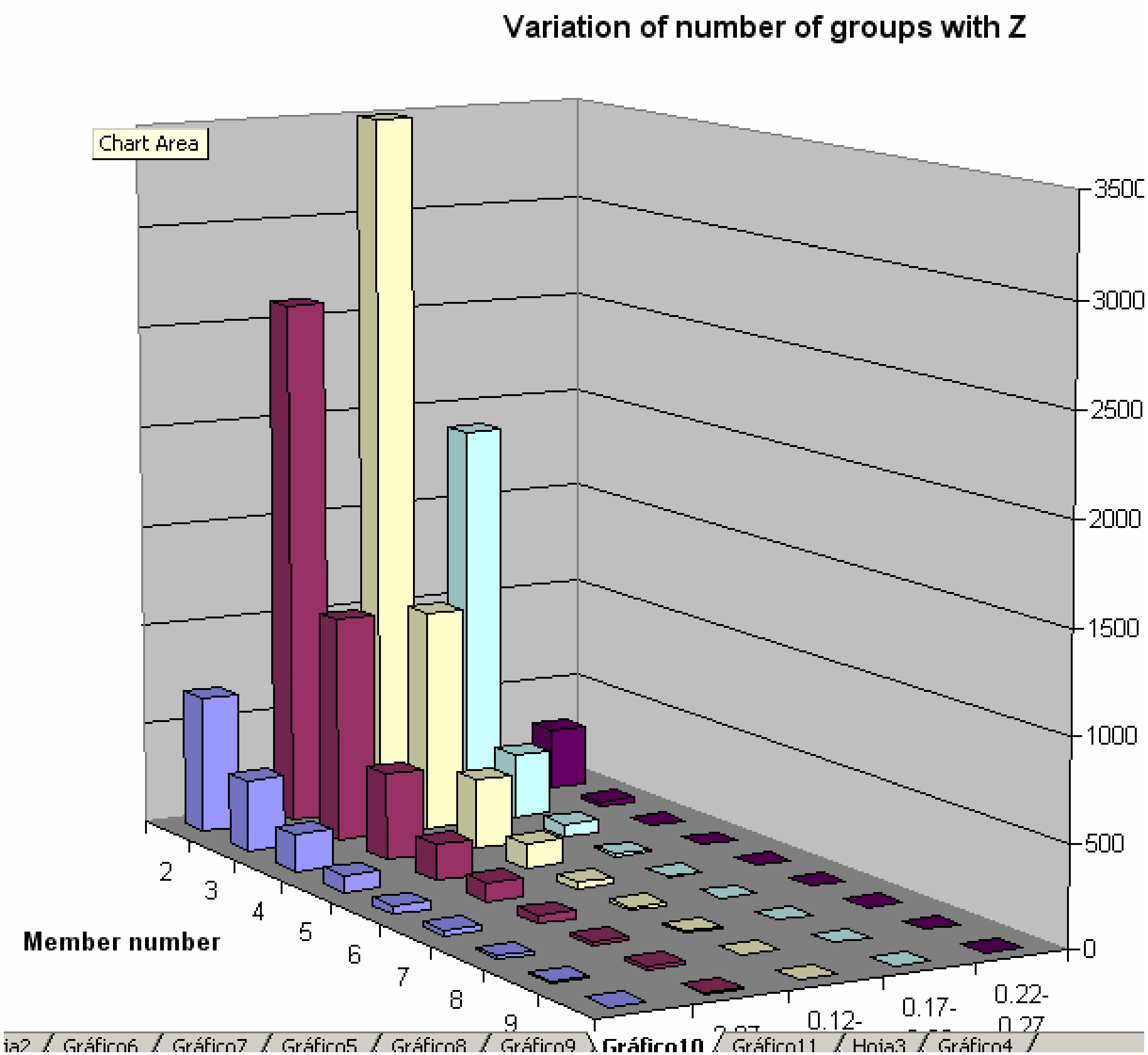

Groups vs. Z
5500
4500
3500
2500
1500
500
-500
Number of groups
1394
4485
5164
2286
322
12
Plot Area
0.02-0.07
0.07-0.12
0.12-0.17
0.17-0.22
0.22-0.27
0.27-0.32
Z interval



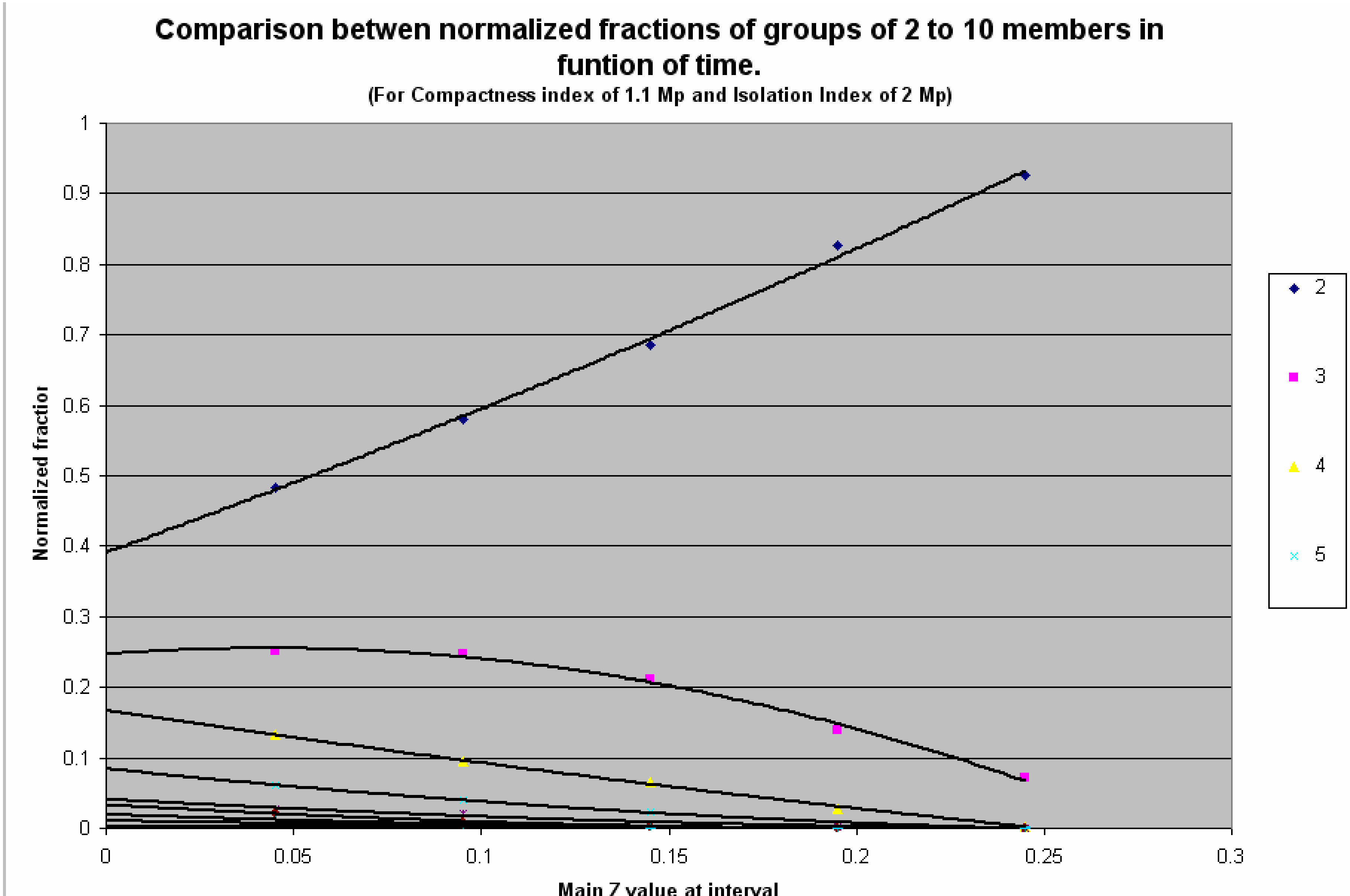
Group Number vs. Z Adjusted with a 6th order polinomial
Plot Area
Number of group
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Z
1394
4485
5164
2286
322
12

Groups at different z

2	676	2603	3543	1889	298	12
3	352	1106	1092	316	23	0
4	185	427	340	62	1	0
5	85	177	122	13	0	0
6	38	92	35	4	0	0
7	29	37	16	1	0	0
8	17	20	8	1	0	0
9	9	18	4	0	0	0
10	3	5	4	0	0	0
	1394	**4485**	**5164**	**2286**	**322**	**12**



Variation of number of groups with Z
Chart Area
3500
3000
2500
2000
1500
1000
500
0
Member number
2
3
4
5
6
7
8
9
0.12-
0.17-
0.22-
0.27
Gráfico6
Gráfico7
Gráfico5
Gráfico8
Gráfico9
Gráfico10
Gráfico11
Hoja3
Gráfico4


Comparison betwen normalized fractions of groups of 2 to 10 members in funtion of time.
(For Compactness index of 1.1 Mp and Isolation Index of 2 Mp)
Normalized fraction
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.05
0.1
0.15
0.2
0.25
0.3
Main Z value at interval
2
3
4
5

Percentage of groups extrapolated to z=0

2	39.1%
3	24.6%
4	16.7%
5	08.4%
6	03.3%
7	01.9%
8	01.0%
9	00.3%

Summary

The algorithm is capable of finding all possible groups (with any number of galaxies, including isolated galaxies), provided we specify the isolation and compactness parameters.

Complementary to FOF. Particularly for studies of the local dynamics of groups (as opposed to Large Scale S.

Can it give us information about the evolution of groups?

Thank You!