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Statistical study of some Lee galaxy groups

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ABSTRACT

Compact groups of galaxies are systems of small number of galaxies close to each other. They are *a* good laboratory to study galaxy properties, such as structure, morphology and evolution which are affected by the environment and galaxy interactions. We applied the tree clustering technique (the Euclidean separation distance coefficients) to test the physical reality of groups and used certain criteria (Sabry et al., 2009) depending on the physical attributes of the galaxies. The sample of the data is the quintets groups of Lee compact groups of galaxies (Lee et al., 2004). It is based on a modified version of Hickson's criteria (Hickson, 1982). The results reveal the membership of each galaxy and how it is related to its group. The tables of groups and their members are included.

Our results indicates that 12 Groups are real groups with real members while 18 Groups have one galaxy that has attribute discordant and should be discarded from its group.

1. Introduction

A Group of galaxies is an accumulation of galaxies that must satisfy a certain criteria. Most of the group - finder methods are made to be applied on a galaxy survey in order to pick out groups of 2–50 galaxies in one group according to this criteria.

There are many different catalogs of galaxy groups made using different methods and criteria depending on position, magnitude, mean separation distances between the center of groups and members, Radii of members and mean surface brightness (Shakhbazian, 1957; Shakhbazyan, 1973; de Vaucouleurs, 1975; Turner and Gott, 1976a, 1976b; Rose, 1977; Karachentsev et al., 1979; Huchra and Geller, 1982; Hickson, 1982; Huchra et al., 1983; Tully, 1987a, 1987b; Rubin et al., 1991; Hickson et al., 1992; Prandoni et al., 1994; Garcia, 1995; Barton et al., 1996; Allam and Tucker, 2000; Focardi and Kelm, 2002; deCarvalho et al., 2005; Deng et al., 2008; Diaz-Gimenez et al., 2012; McConnachie et al., 2009; Wang et al., 2008; Sohn et al., 2015).

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Because most of selection criteria in the group of galaxies catalogues depends on the determine the member's distance from the center of the group and the radii of the members too. So we can see that the uncertainties in determining the radii of galaxies (R) are big especially due to uncertainties in distance determinations (D). The latter depends on the measured velocities (V) and the value of Hubble constant (H_0). This can be added to the fact that one is not sure if these groups are true physical groups or just projection (Sulentic, 1983). Later studies on some of these catalogs showed that some of the galaxies in the groups don't belong to their groups and were thus discarded. This in turn could lead to removing the group from the catalog since it doesn't follow the original criteria (Hickson, 1982; Hickson et al., 1992).

The aim of this paper is to investigate the membership of the galaxies in their groups by applying a clustering analysis technique which makes use of the physical attributes of the galaxies and find the similarity or dissimilarity between members of the same group.

This paper is organized as follows: Section 2 describes the method and data used, Section 3: describe the results obtained while Section 4: describe the conclusion.

2. Data, method and technique

2.1. Data

Lee et al. (2004) presented an objectively defined catalog of Compact groups (CGs) in 153 deg^2 of the Sloan Digital Sky Survey

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(SDSS). They applied a modified version of Hickson's criteria (Hickson, 1982) aimed to finding the highest-density compact groups and thus reducing the number of chance alignments. This catalog contains 175 CGs down to a limiting galaxy magnitude of $r^* = 21$ where r^* is the SDSS r-band. The resulting catalog has a median depth of zmed ~ 0.13.

We used the unweighted pair Group Method using arithmetic average (UPGMA) (Sokal and Michener, 1958; William and Edelsbrununer, 1984; Murtagh 1984; Romesburg, 1984) to measure the similarity or dissimilarity between any two member's astrophysical parameters in each group.

Galaxies in the same groups are supposed to have similar properties that connect them together. Thus our technique depends on studying the similarity between some attributes of objects which seems to form a group or catalogued as a group and testing the similarity between the properties of the members in each group. If these attributes are similar or nearly equal, according to the philosophy of the technique then it may form a group.

This is most effectively defined by the Euclidean distance (separation) coefficient given by the following equation.

$$e_{jk} = \sqrt{\sum_{i=1}^{3} (X_{ij} - X_{ik})^2} \quad (1)$$

This means that to compute e_{jk} for two objects J and K, we use the data in the jth and kth columns of the original data matrix. Adding a third attribute, the Euclidian distance coefficient is given by just adding a third term, i.e.

A generalization of n attribute can take the form

$$e_{jk} = \sqrt{\sum_{i=1}^{n} (X_{ij} - X_{ik})^2} \quad (2)$$

Eq. (2) gives the square root of the sum of the squares of the differences of the values of the n attributes.

The average Euclidean distance coefficient d_{jk} is defined as the average of the squares of the differences, expressed as,

$$d_{jk} = \sqrt{\sum_{i=1}^{n} \left[\frac{(X_{ij} - X_{ik})^2}{n} \right]} \quad (3)$$

In all these equations X_{ij} stands for the value of the ith attribute measured on the jth object and X_{ik} is the value of the ith attribute measured for the kth object, (Romesburg, 1984).

The UPGMA method is used to reanalyze quintet members groups in Lee catalog (Lee et al., 2004). The Euclidean distance coefficient, which one of the clustering techniques, is used. Depending on the Euclidean distance coefficient, we can decide whether we are dealing with a cluster, sub cluster, twin or a triplet, etc.

We used the same criteria in Sabry et al. (2009), (2012), (2016) and Sabry (2016a,b) to test the physical reality of each members in all quintet Lee groups. Which suppose that:

1. Galaxies of coefficients smaller by any value than $e_{av} - \sigma$ are given the name Twin (T). The twin property is here of a relative sense, because it depends on the attributes of the groups. No standardization has been done yet.
2. Galaxies of coefficients of the order $e_{ij} < e_{av}$ given the name pair (P).
3. Coefficients ranging between $e_{av} \leqslant e_{ij} \leqslant e_{av} + \sigma$ are given the name member (M)
4. If the coefficients are $e_{ij} > e_{av} + \sigma$, it is called attribute discordant galaxy (AD). It is the galaxy that, whenever its attributes enters with attributes of the other galaxies in an assembly falsifies the Euclidean coefficients.
5. To decide the triplet character, the Combined Euclidean Distance Coefficient (CEC) should be determined. Although triplets can be seen directly from the coefficients, we found it necessary to determine the CEC to confirm the results and isolate them quantitatively.

Table 1
The attributes of 5 galaxies in LeeCG 6.

Attributes	Object				
	1	2	3	4	5
$(r^* - i^*)$	0.533	0.53	0.506	0.523	0.627
$(i^* - z^*)$	0.446	0.434	0.422	0.468	0.563

Table 2
Resemblance matrix coefficients.

	1	2	3	4
1				
2	0.012369			
3	0.036125	0.026833		
4	0.024166	0.034713	0.049041	
5	0.150083	0.1614	0.185801	0.140858

The following Table 1 is an example to indicate how to deal with. For LeeCG 6 from catalogue of Lee et al. (2004), a segment of the Lee list is shown in Table 1 where, row 1 gives the attributes (the (non-dreddened) SDSS r ~ band and i ~ band model magnitude of the 5 members and row 2 gives the (non-dreddened) SDSS i ~ band and z ~ band model magnitude of the same members.

Applying Eq. (2) gives the Euclidian distance coefficient which shows the degree of similarity or dissimilarity between the two objects.

We get resemblance matrix of LeeCG 6 in Table 2.

Following the criteria we can say that galaxies 1 and 2 make a twin, galaxies 1 and 3 make a pair, galaxies 1 and 4 make a pair too, galaxies 3 and 4 make a pair binary and galaxy 5 may be attribute discordant

3. Results

By Appling the UPGAMA method in the lee Compact Groups which have five members only from the catalog of Lee et al. (2004) and calculating the astrophysical euclidean separation coefficients of each two members in the same group using the total magnitude of the group in the r band and the g-r color index we get the results shown in Table 3 as follows:

Column (1): the number of the euclidean confidents array, column (2): the (non-dreddened) SDSS r ~ band and i ~ band model magnitude of the first object, column (3): the (non-dreddened) SDSS r ~ band and i ~ band model magnitude of the second, column (4): the (non-dreddened) SDSS i ~ band and z ~ band model magnitude of the first object, column (5): the (non-dreddened) SDSS i ~ band and z ~ band model magnitude of the second object, column(6): the calculated Astrophysical euclidean coefficient, column (7) is the average astrophysical euclidean coefficient, column (8): the standard deviation, column (9): the classification of every two galaxies regarding each other and column (10) is the comments.