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Properties of Nearby Groups of Galaxies

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Abstract. The author maintains a catalogue of nearby groups of galaxies, based on galaxy data available at LEDA (Lyon-Meudon Extragalactic Database). The 1998 edition is presented, together with a discussion of the group properties.

1. Introduction

Constructing a galaxy group catalog requires a galaxy catalog as input, giving for each entry celestial coordinates and redshift, and a grouping algorithm.

In this paper I use as input a subset of the publicly available LEDA database (Lyon-Meudon Extragalactic Database), and as algorithm the 'friends-of-friends' procedure initially proposed by Huchra & Geller (1982) and largely used since.

From LEDA galaxies have been extracted with corrected B magnitude $B_T^0 \leq 14.5$; these magnitudes are corrected for internal and galactic absorptions and for K correction. This initial subsample consists of 23559 galaxies.

Only 17968 of them (76.3%) have a measured redshift and can be used in the friends-of-friends algorithm. They form the definitive input sample.

The sample has been checked for incompleteness, which can derive from three different sources: the intrinsic incompleteness of the initial sample, which in turn derives from the LEDA incompleteness, the lack of redshifts, which causes exclusion from the definitive input sample, and the effect of the zone of avoidance near the galactic plane.

The first cause of incompleteness is difficult to estimate in a quantitative manner; however it should be much less than the second one and probably can be disregarded. The reasons for the last statement can be found in a comparison with one of the main sources of LEDA, the CGCG Catalogue (Zwicky et al., 1961-68). It is claimed to be complete at $m = 15.7$, that roughly corresponds to $B_T^0 \leq 14.6$. An incompleteness below this magnitude could be present in the areas not covered by CGCG, in particular in the southern hemisphere. I have counted the galaxies in zones of 1 degree in declination founding that the southern emisphere is more rich than the northern one. Moreover, comparing the 1998 with 1997 edition of LEDA only a small increment is found, and all the new galaxies are in the 14.0-14.5 interval of B_T^0. So the database can be considered 100% complete at $B_T^0 \leq 14.0$, and slightly incomplete for $B_T^0 \leq 14.5$.

The second cause of incompleteness is the most important, but can be remedied only with a great observational effort; it is strongly dependent on magnitude, so that for $B_T^0 \leq 13.0$, 93.9% of the catalogued galaxies have a known redshift, whereas in the bin $14.0 \leq B_T^0 \leq 14.5$ only 62.8% have one; the third one is important only for galactic latitudes less than 15°.

2. Luminosity Function

The luminosity function determination is needed to evaluate in a quantitative way the apparent density variation with distance in this magnitude limited sample of galaxies. In particular it will enter in the functional dependence of the *links* (see below) on distance.

Obviously, for luminosity function determination one needs the absolute magnitudes or distance moduli of galaxies; the latter have been extracted from LEDA where they are calculated from the eliocentric velocity corrected for the Local Group infall onto the Virgo Cluster, assumed equal to 170 km s^{-1}, but neglecting the infall of individual galaxies onto Virgo, and assuming $H_0 = 75$ km s $^{-1}$ (see e.g. Paturel et al. 1997). For the galaxies not having in LEDA the distance modulus, I have found the distance in Tully (1987) and for these still not found I have calculated the modulus using the LEDA recipe.

The luminosity function has been determined using the recipes given in Bardelli et al. (1990). More precisely, a maximum likelihood method has been used assuming a luminosity function parametrized in Schechter form; in this way the Schechter parameters M^* and α have been found. Moreover, a non-parametric method has been used to confirm the applicability of a Schechter form and to find the normalization ϕ^*.

The results are:

$$M^* = -20.64 \pm 0.06 \qquad \alpha = -1.03 \pm 0.04 \qquad \phi^* = 0.0075 \pm 0.0002$$

The errors are at 1 σ and are formal only; this caveat is particularly valid for the ϕ^* error.

3. Algorithm

The friends-of-friends algorithm defines a *couple* of galaxies as two galaxies whose distance is less then a *distance link* and whose velocities differ by less than a *velocity link*. Velocity and distance links have to be defined in a suitable manner and in general vary with the couple mean distance. Two or more couples of galaxies having members in common constitute a group.

In this implementation, following Gourgolhon et al. (1992) and Garcia (1993) the velocity link is kept constant (315 km s^{-1}) and the distance link varies with distance to compensate the apparent decreasing of galaxy density with the increasing distance in a magnitude limited sample. In particular, the dependence of the distance link D_L on the distance d is

$$D_L(d) = D_0 \left(\frac{\Phi(d)}{\Phi_0} \right)^{-1/2}$$

where $\Phi(d)$ is the cumulative luminosity function evaluated at the minimum absolute luminosity still visible at distance d and $\Phi_0 = \Phi(1000 \text{ km s}^{-1})$.

D_0, the distance link at a distance of 1000 km s^{-1}, is taken equal to 0.40 Mpc, giving an overdensity of 20.

4. Group Properties

Out of the 17968 galaxies of the definitive sample, 8912 (49.6%) are isolated, 3074 (17.1%) are in couples and 5980 (33.3%) are in 1092 groups each having at least three members.

Most of groups are nearer than 10000 km s^{-1}

The sizes of groups go from triplets to a grup having 299 members (Virgo Cluster); other 20 groups have at least 20 members.

For each group the following properties are calculated: position on the celestial sphere of its photometric barycenter, mean recession velocity weighted with the luminosity, velocity r.m.s. σ_V; distance (deducted from the distance modulus of each galaxy), total luminosity L, allowing for members fainter than the catalog magnitude limit (a Schechter luminosity function is assumed for each group); polar momentum of inertia; inertial radius r_I; maximum radius (distance of the farthest galaxy from the photometric center); virial radius r_V; gravitational radius r_G; virial mass M; mass to light ratio M/L; crossing time t_{cr}; mean type; ratio between minimum and maximum axis of inertia, as an evaluation of its shape; orientation, i.e. angle between north and maximum inertial axis of the group.

Some of the formulas used are quite obvious, requiring elementary statistical or geometrical algorithms; the others can be found in Gougoulhon et al. (1988).

The main properties are reported in table I; these are compatible with the values given in literature and in my previous paper on this topic (Giudice 1997). remember that the adopted value for Hubble constant is $H_0 = 75$ km s^{-1}.

Table 1. Group properties.

Quantity	Unit	Lower Quart.	Geom. Mean	Median	Arithm. Mean	Upper Quart.
σ_V	km s^{-1}	93	144	161	187	246
r_V	Mpc	0.64	1.11	1.28	1.69	2.15
r_I	Mpc	0.25	0.40	0.43	0.52	0.69
r_G	Mpc	1.76	3.01	3.29	4.47	5.70
M/L	solar	32	82	108	270	247
t_{cr}	H_0^{-1}	0.15	0.28	0.27	0.45	0.48

In the M/L versus t_{cr} plane (fig. 1a) the dynamical status of the groups can be studied (see e.g. Mamon 1994 and 1995). A collapsing sphere moves in this plane in a characteristic way, which can be studied either analytically (Gunn & Gott 1972) or numerically. In this plane the points representing groups lie on or below the curve of the spherical collapse. This can partly explained by projection effects or by a different intrinsic mass to light ratio. So, groups with t_{cr} less than an Hubble time can be considered in turn-around, groups with crossing time in the interval 0.1 - 1.0 Hubble times can be regarded as collapsing, those with t_{cr} less than 0.1 Hubble times can be regarded as virialized. Groups with very high M/L may be still in expansion.

Most groups, so, are not virialized systems. Nevertheless, in the M/L versus M plane they lie in a plane resembling the fundamental plane of galaxies (fig. 1b). The units on the axes are correlated with the κ variables of Bender et al. (1992) since $\kappa_1 \propto \log M$ and $\kappa_3 \propto \log M/L$. In this case I have not determined a photometric radius due to the sparseness of most groups; the virial radius has

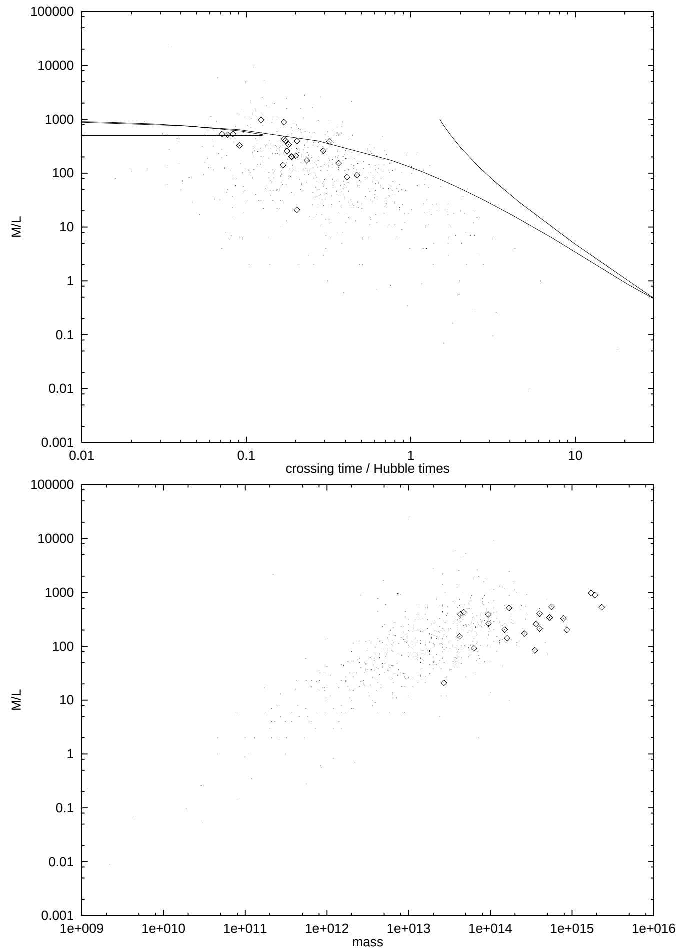

Figure 1. (a) Dynamical evolution of a collapsing sphere compared with the locus of groups. (b) the 'fundamental plane' of groups. Note than greater groups lye on a rotated plane. In both figures groups with $n_{gal} \geq 20$ are displayed as squares.

bee used instead. The central velocity dispersion used in elliptical galaxies has been replaced by the velocity r.m.s. σ_V.

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