The Local Group and other neighboring galaxy groups

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ABSTRACT

Over the last few years, rapid progress has been made in distance measurements for nearby galaxies based on the magnitude of the tip of red giant branch stars. Current CCD surveys with HST and large ground-based telescopes bring $\sim 10\%$-accurate distances for roughly a hundred galaxies within 5 Mpc. The new data on distances to galaxies situated in (and around) the nearest groups: the Local Group, M81 group, CenA/M83 group, IC342/Maffei group, Sculptor filament, and Canes Venatici cloud allowed us to determine their total mass from the radius of the zero-velocity surface, $R_0$, which separates a group as bound against the homogeneous cosmic expansion. The values of $R_0$ for the virialized groups turn out to be close to each other, in the range of 0.9 – 1.3 Mpc. As a result, the total masses of the groups are close to each other, too, yielding total mass-to-blue luminosity ratios of $10 – 40 M_\odot/L_\odot$. The new total mass estimates are 3 – 5 times lower than old virial mass estimates of these groups. Because about half of galaxies in the Local Volume belong to such loose groups, the revision of the amount of dark matter (DM) leads to a low local density of matter, $\Omega_m \simeq 0.04$, which is comparable with the global baryonic fraction $\Omega_b$, but much lower than the global density of matter, $\Omega_m = 0.27$.

To remove the discrepancy between the global and local quantities of $\Omega_m$, we assume the existence of two different DM components: 1) compact dark halos around individual galaxies and 2) a non-baryonic dark matter “ocean” with $\Omega_{dm1} \simeq 0.07$ and $\Omega_{dm2} \simeq 0.20$, respectively.

1. Introduction

In rich clusters of galaxies, virial mass estimates agree well with independent determinations of the cluster mass made from the X-ray flux of hot intracluster gas, and from weak gravitational lensing effects. A typical ratio of the total mass-to-blue luminosity for rich clusters, $M/I/L_B \sim 250 M_\odot/L_\odot$, extrapolated over the whole volume of the universe, yields the mean density of matter $\Omega_m \sim 0.25$, in the excellent concordance with parameters of the standard $\Lambda$CDM model: $\Omega_m = 0.27$, $\Omega_\Lambda = 0.73$ (Spergel et al. 2003). However, about 85% of galaxies are situated outside the rich clusters. Roughly a half of them belong to groups of different size and population, while the remaining half are scattered in diffuse (unvirialized) “clouds” and “filaments” usually called the “field”. Until recently, application of the virial theorem to galaxy groups remained the only way to trace the dark matter distribution on scales of 0.1 – 1 Mpc. Measurements of the total mass of individual groups via their X-ray flux or weak gravitational lensing have not lead yet to distinct results.

In the case of our Local Group (LG), Lynden-Bell (1981) and Sandage (1986) proposed to determine its total mass using a method, which is

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based on a measurement of the radius of the “zero-velocity surface”, \( R_o \), where the overdensity of the group has halted expansion and infall is about to commence. Under the assumption of spherical symmetry the total mass of a group can be expressed in terms of the radius \( R_o \), the age of the Universe \( T_o \), and the Gravitational constant \( G \) as

\[
M_t = \left( \frac{\pi^2}{8G} \right) \times R_o^3 \times T_o^{-2}.
\]

Application of this method to the LG as well to other groups requires accurate distances and radial velocities for all galaxies surrounding a group. Such data is now accessible for several nearby groups by using the luminosity of stars at the tip of the red giant branch (TRGB) as standard candles.

Over the last 5 years, searches for additional nearby dwarf galaxies, made on the POSS-II \& ESO/SERC plates by Karachentseva \& Karachentsev (1998; 2000), and also results of “blind” HI surveys of the southern sky, and the Zone of Avoidance by the HIPASS team (Kilborn et al. 2002), as well as other wide-field sky surveys, lead to a doubling of the population of known galaxies in the Local volume. Basic observational data on 450 Local volume galaxies with distances less than 10 Mpc are presented in the Catalog of Neighboring Galaxies (Karachentsev et al. 2004).

The new quantity and quality of observational data on nearby galaxy distances and radial velocities allowed us to determine virial and total masses of four of the nearest complexes: Milky Way+M31 (Karachentsev et al. 2002c), M81+NGC2403 (Karachentsev et al. 2002a), CenA+M83 (Karachentsev et al. 2002b), and IC342+Maffei (Karachentsev et al. 2003d), as well as of two other nearby scattered galaxy systems: M96 = the Canes Venatici I cloud (Karachentsev et al. 2003a) and NGC253 = the Sculptor filament (Karachentsev et al. 2003c). Below we discuss the results of mass determination for all six nearest groups made via internal and external galaxy motions.

2. Some particular properties of the neighboring groups

Our Galaxy, the Milky Way, and the Andromeda nebulae, M31, together with their suites of dwarf companions are usually combined into the united dynamical system, the Local Group (=LG). The basis for this is the observed mutual approaching of two the giant galaxies with a velocity of 123 km s\(^{-1}\). However, such a definition has an apparent disadvantage because the dynamical center of the LG turns out to be in emptiness, and individual motions of dwarf galaxies occur around the Andromeda and Milky Way themselves. For this reason, we prefer to consider both the giant spiral galaxies as the centers of two independent groups forming together the Local complex of galaxies.

2.1. The Milky Way group.

Different properties of companions to our Galaxy are described in detail in a monograph by van den Bergh (2000) “The galaxies of the Local Group”. We will discuss here only the most general parameters of the group. The list of galaxies dynamically associated with the Milky Way is presented in Table 1. Its columns contain: (1) galaxy name; (2) morphological type; (3,4) radial velocities with respect to the Galaxy center and regarding to the LG centroid, respectively, with the apex parameters adopted in the NASA Extragalactic Database (NED); (5) absolute magnitude corrected for the Galactic extinction (Schlegel et al. 1998) and internal galaxy extinction in the manner, which takes into account the galaxy inclination, as well as luminosity (Karachentsev et al. 2004); (6) distance to the galaxy in Mpc with indication of the method used: from the luminosity of cepheids (cep), from the luminosity of the tip of the red giant branch (rgb) as given in (Karachentsev et al. 2004); (7) the so called “tidal index”:

\[
\Theta_i = \max\{\log(M_k/D_{ik}^2)\} + C, \quad (i = 1, 2,...N)
\]

where \( M_k \) is the total mass of any neighboring galaxy separated from the considered galaxy by a space distance \( D_{ik} \); for every galaxy “i” we found its “main disturber” (=MD), producing the highest tidal action; the value of the constant \( C \) is chosen so that \( \Theta = 0 \) when the Keplerian cyclic period of the galaxy with respect to its main disturber equals the cosmic Hubble time, \( 1/H \). In this sense, galaxies with \( \Theta < 0 \) may be considered as isolated objects of the general field. Besides 15 members of the Milky Way group, we indicate under the horizontal line at the bottom of Table an-
other four galaxies: Tucana, SagDIG, SexA, and SexB, for which the Milky Way is also the MD. All of them move away from our Galaxy, taking apparently part in the general cosmic expansion. Note that the LMC stands out as the MD with respect to the Milky Way and the SMC.

By luminosity, the Milky Way appreciably dominates over the surrounding objects: the net luminosity of its 14 companions is an order magnitude lower than the Milky Way luminosity itself. The radius of gravitational prevalence of the Milky Way extends to ~700 kpc, while the radial velocity dispersion of the companions is 86 km s\(^{-1}\) with regard to the Galaxy center and 76 km s\(^{-1}\) with respect to the LG centroid. Applying the virial theorem, we obtain for our group the mass estimate

\[ M_{\text{vir}} = 3\pi N \times (N - 1)^{-1} \times G^{-1} \times \sigma_v^2 \times R_H, \]

where \( \sigma_v^2 \) is the dispersion of radial velocities with respect to the group centroid, and \( R_H \) is the mean projected harmonic radius. This relation assumes a spherical symmetry of the group and a random orientation of velocity vectors for the group members. Adopting \( R_H = (\pi/4)(D_{\text{vir}}^{-1})^{-1} = 68 \) kpc, gives us \( M_{\text{vir}} = 93 \times 10^{10} M_\odot \). For arbitrarily oriented Keplerian orbits of companions with the eccentricity \( e \) the robust estimator of mass is

\[ M_{\text{orb}} = (32/3\pi) \times G^{-1} \times (1 - 2e^2/3)^{-1} \langle R_p \times \Delta V_r^2 \rangle. \]

Adopting \( e = 0.7 \) as the average eccentricity, we derive for the companions of the Milky Way \( M_{\text{orb}} = 96 \times 10^{10} M_\odot \) in excellent agreement with the previous estimate.

However, two circumstances exist that force one to suppose that the two evaluations obtained overestimate the mass of our group. Firstly, all the companions to Milky Way (but for NGC 6822) are situated in an elongated volume with an axial ratio 8:3:1, known as the polar Magellanic stream. Secondly, when observing orbital motions of the companions from inside, if orbits are strongly elongated then we see almost the full vectors of their velocities, i.e. the statistical relationship \( \sigma_v^2 = (1/3)\sigma_s^2 \) between radial and spatial velocity dispersions is not satisfied.

2.2. The Andromeda group.

Over the last five five new companions to M 31: And V, Cas dSph, Peg dSph, Cetus, and And IX (Zucker et al. 2004) have been discovered. As a result, the present population of M 31 group exceeds the population of the group around our Galaxy. The list of 19 members of the Andromeda group is given in Table 2. The following information is provided in the Table: (1) galaxy name; (2) morphological type; (3) radial velocity with respect to the LG centroid; (4) absolute magnitude after corrections for internal and external extinctions; (5) distance from the observer; (6) angular separation from the M 31, and (7) the tidal index. As it is seen, the maximum angular separation of the most remote companions to Andromeda reaches one radian. At the bottom of the table under the horizontal line another four dwarf galaxies are given: DDO 210, KKH 98, 25, and KK 230, for which the M 31 is the MD. However, their crossing time with respect to the Andromeda exceeds the age of the universe, which does not permit us to consider them physical members of the M 31 group. For 18 companions to Andromeda their mean projected linear separation is 254 kpc, while the mean harmonic radius is 42 kpc. The radial velocity dispersion in the M 31 group, 77 km s\(^{-1}\), is nearly the same as in the Milky Way group. Applying the above mentioned relations, we obtain the mass estimates: \( M_{\text{vir}} = 57 \times 10^{10} M_\odot \) and \( M_{\text{orb}} = 111 \times 10^{10} M_\odot \). Studying the kinematics of the giant stellar stream around the M 31, Ibata et al. (2004) measured the mass of Andromeda halo on the scale of 125 kpc. Their estimate \( M_{125} = (75^{+35}_{-13}) \times 10^{10} M_\odot \) agrees well with the virial and orbital mass estimates. Note also, that almost the same mass estimates have been derived by Evans & Wilkinson (2000), Cote et al. (2000), and Evans et al. (2000) on the scale of ~50 kpc based on the motions of companions and globular clusters of M 31.

2.3. The M 81 group.

Kinematics of galaxies around the M 81 has been considered by Karachentsev et al. (2002a). Recently, several new galaxies of the group have been imaged with the Advanced Camera for Survey at the HST. A slightly renewed parameters of the M 81 group members are summarized in Table 3, where column designations are the same as in previous tables (In column 6 “mem” means that the galaxy distance was ascribed from its membership as the mean distance to the group.) The last
column contains notes regarding some objects, for which the main disturber is not M 81, but other nearby galaxies. As it is seen, in the number of members, N = 29, the M 81 group exceeds both the Milky Way group and the Andromeda group. Below the horizontal line in the Table 3, we give another six galaxies which may belong also to the far periphery of the M 81 group. Some of them are associated with another spiral galaxy NGC 2403 rather than with M 81 itself, forming a scattered system (“flock”), which moves towards the M 81. Both from the radial velocity dispersion, $\sigma_r = 91$ km s$^{-1}$, and from the linear projected radius, $R_p = 211$ kpc, the M 81 group is similar to the Milky Way and the M 31 groups. Virial and orbital mass estimates for the M 81 group are $117 \times 10^{10} M_\odot$ and $197 \times 10^{10} M_\odot$, respectively.

2.4. The CentaurusA/M83 complex.

The structure and kinematics of this nearby galaxy complex have been discussed by Karachentsev et al. (2002b). The group of galaxies around M 83 (=NGC 5236) actually has the same mean radial velocity (+308 km s$^{-1}$) as the Cen A group (+312 km s$^{-1}$), but the distance from us appreciably larger (4.56 Mpc) than that of the Cen A group (3.66 Mpc). The updated lists of 28 and 14 members of both the groups are presented in Tables 4 and 5, respectively. Notes in the last column indicate group members having another main disturbers (not Cen A or M 83). Under the horizontal lines there are some galaxies with larger projected separations which may be associated with the complex too.

In the Cen A group its mean linear projected radius, 290 kpc, and radial velocity dispersion, 105 km s$^{-1}$, are markedly greater than in the M 83 group (164 kpc and 71 km s$^{-1}$) that leads to a considerable difference in mass estimates of the groups: 489 (vir) and 288 (orb) in $10^{10} M_\odot$ for the Cen A, and 109 (vir) and 100 (orb) in $10^{10} M_\odot$ for the M 83 group, respectively. Such a difference is consistent with the assumption of Bahcall et al. (1995) that giant elliptical galaxies have a mass 2 – 3 times larger per unit luminosity than giant spiral galaxies.

2.5. The IC342/Maffei complex.

This nearby binary group is situated in the zone of strong Galactic extinction, which complicates analysis of its dynamics. Properties of the structure and kinematics of the complex have been considered by Karachentsev et al. (2003d). The last summary of data on distances, radial velocities and luminosities of galaxies around IC342/Maffei was published by Karachentsev et al. (2004). These data are reproduced in Table 6 and 7. Here, distance estimates made from luminosity of the brightest stars or via Tully-Fisher and Faber-Jackson relations are indicated as “bs”, “tf”, and “fj”, respectively. For three galaxies: UGCA 86, KKH 37, and KKH 6 we use here new distance estimates obtained with the ACS HST.

At present, both the groups around the giant face-on spiral IC 342, and around the pair of E+S galaxies Maffei 1 and Maffei 2 contain eight members each. Their numbers may be increased after a careful survey of this region in the HI line. Two galaxies, KKH 37 and KKH 6, with negative tidal indexes (in bottom of tables 6 and 7) do not belong, apparently, to the bound members of the complex.

Both the groups have a rather low dispersion of radial velocities, 54 km s$^{-1}$ (IC 342) and 59 km s$^{-1}$ (Maffei), and quite typical mean linear projected separations, 322 kpc and 104 km s$^{-1}$, respectively. The virial and orbital mass estimates for the groups come to 57 and 95 (IC 342), and 65 and 135 (Maffei) in units of $10^{10} M_\odot$.

2.6. The Sculptor filament.

As it was shown by Jerjen et al. (1998), a conglomeration of bright galaxies in Sculptor is a loose filament stretched along the line of sight and involved in the general cosmic expansion. According to Karachentsev et al. (2003c), the giant spiral galaxy NGC 253 and its five companions form a semi-virialized core of the filament. Data on NGC 253 and its companions are given in Table 8. In its lower part we indicate also five more remote galaxies associated with the group core. At a radial velocity dispersion 54 km s$^{-1}$ and a mean harmonic projected radius $R_H = 347$ kpc, estimates of mass of the group are 332 (vir) and 153 (orb) in units of $10^{10} M_\odot$. However, both the mass estimates look extremely unreliable since the group...
crossing time, $T_{\text{cross}} = \frac{\langle R_p \rangle}{\sigma_v} = 6.6$ Gyr, is too long for the virialization of the system. Note also, that inclusion of 5 more distant galaxies under the horizontal line in Table 8 brings the crossing time closer to the Hubble time, $\sim 13$ Gyr.

### 2.7. The Canes Venatici I cloud.

This very loose extended system mainly inhabited by dwarf irregular galaxies was studied by Karachentsev et al. (2003a). On the map of the sky region presented by the authors the CVnI cloud occupies an area of about 35° in diameter with the center near the brightest galaxy M 94 (=NGC 4736). For the sample of 34 members of the cloud, Karachentsev et al. (2003a) derived the radial velocity dispersion 50 km s$^{-1}$, the mean linear projected radius 760 kpc, and the mass estimates: $360 \times 10^{10} M_\odot$ (vir) and $190 \times 10^{10} M_\odot$ (orb). The crossing time for the CVnI cloud is 15 Gyr, therefore, the system is rather in the free Hubble expansion than in a state of dynamical equilibrium.

Arrangement of galaxies by their tidal index shows that the brightest galaxy of the CVnI cloud, M 94, is the main disturber relative only to 10 neighboring galaxies. All of them are presented in Table 9, where column designations are the same as in the previous tables. For 9 members of the M 94 group with positive tidal indices, we obtain the radial velocity dispersion 56 km s$^{-1}$, the mean harmonic projected radius 346 kpc, the mass estimates $267 \times 10^{10} M_\odot$ (vir), $322 \times 10^{10} M_\odot$ (orb), and the crossing time 6.9 Gyr. Thus, even the central region of the CVnI cloud can not be considered as dynamically relaxed sub-system.

### 3. “Bald” dwarfs in the groups

In all the groups, but for the strongly obscured complex IC342/Maffei, there is an appreciable number of diffuse dwarf spheroidal galaxies (dSph). Measurement of radial velocities for these smooth objects of low surface brightness is an extremely hard observational task due to absence in them of contrast details, as well as lack of neutral hydrogen. It is only in the closest dSph galaxies that one can measure the radial velocity from a globular cluster (when available) or the brightest stars. The majority of such “bald” dwarfs are concentrated in compact groups and Virgo cluster (Karachentseva & Sharina, 1987). This fact suggests we can assign to “bald” dwarfs the mean distance of the group, in whose visible perimeter they are situated. Measurements of distances to dSphs with the HST from TRGB generally confirm their membership in corresponding groups.

The total number of dSph+E companions in the complexes: Milky Way/M31, M81, CenA/MS3, and IC342/Maffei amount to 55 against 58 companions of dIr+S types. “Bald” companions show stronger concentration toward the principal galaxy as compared to gas-rich ones. Thus, the medians of projected separations for them equal to 167 kpc (dSphs) and 210 kpc (dIrS). One dSph object, Cetus, is at a projected distance of over 500 kpc from the main galaxy of the group. The observed difference between the median projected separations (167 kpc vs. 210 kps) may be considered as insignificant. Nevertheless, among 233 galaxies having distances to us within 5 Mpc, there are four only isolated early-type galaxies: NGC 404 (Θ = –1.0, MD = Maffei 2), KKs3 (Θ = –0.3, MD = NGC 1313), KK 258 (Θ = –0.9, MD = NGC 253), and Tucana (Θ = –0.1, MD = Milky Way). All of them are peculiar objects requiring special detailed study.

As an aside, it should be noted that the observed number of “bald” dwarfs in the group tends to increase with the luminosity of bulge of the main group member, and to decrease with crossing time of the group, which has a quite obvious evolutionary interpretation.

### 4. Common properties of the nearest galaxy groups

Some general characteristics of the discussed groups are listed in Table 10. The following information is provided in the Table lines: (1,2) mean group distance from us and from the LG centroid (in Mpc); when determining the LG centroid, we assumed that the total masses of the M 31 and the Milky Way are as 5 : 4 (Karachentsev & Makarov, 1996); (3) distance of group center from the plane of the Local Supercluster (in Mpc); (4,5) the known total number of members in the group and galaxies of early-type (E+dSph); (6,7) morphological type and absolute magnitude of the brightest member; (8) rotation velocity of the main galaxy (in km s$^{-1}$); (9) radial velocity of...
the principal member relative to the LG centroid (km s\(^{-1}\)); (10) mean radial velocity of the group in the system of rest LG (km s\(^{-1}\)); (11) dispersion of radial velocities in the group (in km s\(^{-1}\)); (12) mean projected separation of the companions from the principal galaxy (in kpc); here the mean spatial distance of the Milky Way companions is multiplied by (\(\pi/4\)) to account for projection effects; (13) integrated blue luminosity of the group; (14,15) virial and orbital mass estimates (in \(10^{10}M_\odot\) units); (16,17) virial and orbital mass-to-luminosity ratio in solar units; (18) crossing time, \((R_p)/\sigma_v\), in Gyr.

As it was to be expected, two loose systems: Sculptor filament and CVnI cloud are characterized by the greatest crossing time, which exceeds half the Hubble time. These two systems (the last right columns in Table 10) have obviously not reached an dynamical equilibrium, and we will no discuss them further. Comparison of the parameters of the remaining groups allow us to make the following statements.

a) The centers of all the groups reside in a narrow layer (\(\pm 0.33\) Mpc) thick with respect to the Local supercluster plane, which accounts for only 10% of the volume considered.

b) Judging by the principal characteristics: dimension, luminosity, velocity dispersion, and content of dSphs, the Local Group is a typical representative of nearby groups, where one main galaxy dominates.

c) Virial/orbital mass-to-luminosity ratios for nearby groups lies within \([8-88]\) \(M_\odot/L_\odot\). Their median \(29\) \(M_\odot/L_\odot\) is 3 – 5 times as small as the old estimates made by Huchra & Geller (1982) and Tully (1987) for groups of the same luminosity.

d) The binary structure looks to be a common feature of nearby groups. Some paired groups: Milky Way + M 31 and M 81 + NGC 2403, manifest the mutual approach of their principal galaxies, and the kinematic status of the others is open to question.

e) The crossing times in neighboring groups are concentrated within [1.8 – 5.9] Gyr, while the median, 2.3 Gyr, is 6 times as small as the Hubble time, which enables these groups to be regarded as advanced in their dynamical evolution.

5. Nearby groups as tools for cosmology

Precise measurements of distances and radial velocities for galaxies surrounding a group permits one to determine the radius of zero-velocity surface, \(R_o\), which separates the group from the general cosmic expansion. Determinations of \(R_o\) for the six nearest groups were performed by Karachentsev et al. (2002a,b,c, 2003a,b,c). The results are collected in Table 11. Its first and second lines present the total mass of each group/complex estimated by the virial theorem or from orbital motions of companions around the principal galaxy. (As the total mass of the LG, we use the virial/orbital mass estimates of the M31 group multiplied on the factor 1.8, which takes into account the expected mass ratio, 4:5, for the Milky Way and the M31). The third line contains data on the turn-over radius \(R_o\) and its error. The fourth line gives the total mass calculated from \(R_o\) as \(M_o = (\pi^2/8G)R_o^3/T^2_o\), where the age of the universe is adopted to be (13.7\(\pm 0.2\)) Gyr (Spergel et al. 2003). The last two lines indicate the total blue luminosity of the group/complex and the total mass-to-luminosity ratio, respectively. Figure 1 shows the relationship between mass estimates for the groups made by two quite independent series of observational data: from internal motions of group members (horizontal) and from external motions of galaxies surrounding the group. Two complexes which are likely unbound: the Canes Venatici I cloud and the Sculptor filament are shown by the dotted boxes.

All four likely virialized systems: Milky Way/M31, M81/NGC2403, CenA/M83, and IC342/Maffei manifest quite satisfactory agreement between independent mass estimates. In two apparently unvirialized expanding complexes (Sculptor and CVnI), their virial/orbital mass estimates turn out to be 3 – 8 times larger than the total masses estimated via \(R_o\). The derived total mass-to-luminosity ratios show a surprisingly low scatter, being ranked inside [9 – 37] with a median of 19 in solar units. The ratio of the sum of the total masses for the four complexes to the sum of their total luminosity is \(21M_\odot/L_\odot\).

As we have already noted, all the groups under discussion are situated in the sphere of radius 5 Mpc. From the presently available data, this volume contains 233 galaxies. About half
of them, 121/233, are members of the LG, the M81/NGC2403 group, the CenA/M83 group, and the IC342/Maffei group. Besides them, 62 more galaxies in the 5 Mpc-sphere (i.e. 27%) belong to smaller multiple systems around NGC 3109, UGC 8760, NGC 784, and UGC 3974, and two expanding complexes in Sculptor and Canes Venatici. Thus, the relative number of the group members in the Local volume accounts for about 78%, and only 22% of nearby galaxies can be considered to be the population of the general “field”.

According to the “Catalog of Neighboring Galaxies” (Karachentsev et al. 2004), the integrated luminosity of all galaxies within 5 Mpc is \( \Sigma L(5 \text{ Mpc}) = 46 \times 10^{10} L_\odot \). From the fifth line of Table 11, the integrated luminosity of the virialized groups is \( 30 \times 10^{10} L_\odot \) or 65% of the total luminosity of the volume. With allowance made for the Sculptor filament and the CVnI cloud, the fraction of local luminous matter in systems increases to 82%. The numbers presented reflect the known effect of segregation of galaxies by luminosity, with the concentration of dwarf galaxies in groups less pronounced than for giant galaxies.

One of the remarkable properties of the spatial distribution of galaxies is its fractality. On different scales, groups/clusters look like dense knots in filaments which concentrate towards sheets, forming as a whole a fractal “cosmic web” pattern. This general picture is valid for the Local volume of radius 5 Mpc around the local “pancake”, which occupies \( \Sigma \rho = 72 \text{ km s}^{-1} \text{ Mpc}^{-1} \). The critical density of matter, \( \rho_c = (3H_0^2/8\pi G) \), is equal to \( 14.3 \times 10^{10} M_\odot/ \text{ Mpc}^3 \). Consequently, the mean local density of matter is only \( \rho(5 \text{ Mpc}) = 0.10 \rho_c \).

It follows from the data of the Catalog (Karachentsev et al. 2004) that the mean density of luminosity within 5 Mpc equals \( 8.7 \times 10^8 L_\odot/ \text{ Mpc}^3 \). Comparing this with the mean luminosity density estimated from the Sloan Digital Sky Survey (Blanton et al. 2003) and the Millenium Galaxy Catalogue (Liske et al. 2003), we obtain a ratio \( \rho_L(5 \text{ Mpc})/ \rho_{L, \text{glob}} = 4.3 \pm 0.3 \). Here we took into account that ignoring internal extinction in galaxies in SloanDSS and MGC causes underestimates of \( \rho_{L, \text{glob}} \) by a factor of 1/3. Supposing that on different scales the mass density is strictly proportional to the luminosity density (no biasing), then the mean density of matter contained in the groups leads to the value of global density of matter of about 0.025 of the critical density.

6. Peculiar motions of the groups

Over the past few years, it has repeatedly been noted (Sandage, 1986, Karachentsev & Makarov, 2001, Ekhholm et al. 2001, Karachentsev et al. 2003b) that the local Hubble flow is rather cold with a dispersion of radial velocities less than 70 \( \text{ km s}^{-1} \). As can be seen from the data of Table 10, the dispersion of virial velocities in nearby groups has approximately the same value. For the galaxies situated outside the groups, the estimates of \( \sigma_v \) are chiefly determined by errors of measurements of distances to galaxies, and the role played by these errors enhances with distance. In the immediate vicinities of the LG on scales of 2 – 3 Mpc, the radial velocity dispersion for the field galaxies is only 25 – 30 km s\(^{-1}\) (Karachentsev et al. 2002c).

Apparently, it is not always easy to distinguish between true isolated galaxies and members of loose groups. For this reason, it is interesting to examine the behaviour of group centers, but not individual galaxies on the Hubble diagram. Such a Hubble relation is displayed in Figure 2 using the data of lines 2 and 10 of Table 10. The errors of measurements of the mean velocities of the groups are not large (\(< 10 \text{ km s}^{-1}\)), and we do not show them here. The horizontal bars correspond to the errors of the average distance of the groups being
usually $\sim 10\%$. The line corresponds to the Hubble relation with $H_0 = 72$ km s$^{-1}$ Mpc$^{-1}$ and a LG zero-velocity surface at 0.95 Mpc. Dispersion of radial velocities obtained from these data for the centroids is 25 km s$^{-1}$ after quadratic subtracting of distance errors. The low values of “thermal” velocities of the galaxies in the field and the centers of the groups are remarkably consistent with the low estimates of the mean density of matter in the Local volume. Note that the global value $H_0 = 72$ km s$^{-1}$ Mpc$^{-1}$ fits fairly the local Hubble flow.

7. Some other nearby groups

Above, we considered the nearest groups only, because the quality of data on distances of galaxies situated beyond 5 Mps is rather unsatisfactory. For instance, the majority of galaxies in the layer $D = 5 - 10$ Mpc have no direct individual distance estimates at all. Nevertheless, the Catalog of Neighboring Galaxies provide us with data on tidal indices and the names of the main disturber for each galaxy within 10 Mpc, giving an idea of the location and population of more distant groups. Without discussing characteristics of these groups, let us enumerate only the most representative of them containing four or more members: NGC 672 (5), NGC 2784 (6), NGC 3115 (7), NGC 3368/3412/3489= Leo-I group (37), NGC 4244 (4), NGC 4594 (7), M101 (5), and NGC 6946 (7). Here, every group is noted by the name of the brightest member, and the number of group members with $\Theta > 0$ is shown in brackets. Apart from the Leo-I group, all others resemble the Local Group by a prevalence of a single galaxy. Linear dimensions, velocity dispersions and luminosities of the groups are similar to parameters indicated in Table 10. Only the Leo-I group is different from the others by the presence of several giant members of early (E,S0,Sa) types, comparable to each other in luminosity. This group, resembling a mini-clusters, is characterized by the projected radius of 350 kpc, the radial velocity dispersion of 130 km s$^{-1}$, and the virial mass-to-luminosity ratio of $107M_\odot/L_\odot$ (Karachentsev & Karachentseva, 2004). The galaxy groups of the Leo-I-type are much more sparse than groups of the LG-type: in the 10 Mpc volume around us the ratio of their numbers is approximately 1:30. Hence, the Leo-I-type groups make a contribution of minor importance to the mean density of matter.

Properties of groups situated within the Local Supercluster have been recently studied by Makarov & Karachentsev (2000). They applied a new algorithm (similar to a criterion $\Theta > 0$) to a distribution of 6320 galaxies with radial velocities $V_{LG} < 3000$ km s$^{-1}$ and selected 839 groups. For the groups with population $N \geq 5$ the following median characteristics were derived: the radial velocity dispersion of 86 km s$^{-1}$, the projected harmonic radius of 250 kpc, the crossing time of 1.5 Gyr, and the virial mass-to-luminosity ratio of $50 M_\odot/L_\odot$. Therefore, the characteristics of the nearest groups do not differ essentially from the main dynamical characteristics of more representative sample covering a scale of $\sim 30$ Mpc.

8. Conclusions: the nearby groups as dark matter tracers

As it has been mentioned above, determinations of mass of the galaxy clusters, made by different ways, yield mutually concordant results with a typical mass-to-luminosity ratio about $(250 - 300) M_\odot/L_\odot$ in the $B$ band. Assuming the linear proportionality between dark and luminous matter this leads to the global density of matter in the universe $\Omega_m \simeq 0.27$, in agreement with WMAP (Spergel et al. 2003). However, only $(10 - 15)\%$ of all galaxies are concentrated in rich clusters. Hence, the collective input of clusters into $\Omega_m$ consist of 0.03 – 0.04 only. Most of galaxies, about $(50 - 70)\%$, are situated in groups of different size and population, with the LG and other nearest groups typical representatives.

Recent accurate measurements of distances to galaxies open a possibility to measure group masses by two independent manners: via internal and via external galaxy motions. Applied to the well studied neighboring groups, both the methods manifest good mutual agreement. However the mass-to-luminosity ratios for groups turn out to be one order less than for clusters. It means that the hypothesis assuming linear proportionality of dark and luminous matter on different scales is not valid.

Since the “external” method estimates the total mass of group on a scale of $R_o \sim 1$ Mpc, but the “internal” method yields virial/orbital mass estimate on a lower scale, $\langle R_o \rangle \simeq 200$ kpc, then the dark matter in groups is tightly tied to the lumi-
nous one. The case of the nearest group around Andromeda shows that the total mass of the M31 halo, $7.5 \times 10^{10} M_{\odot}$ is reached already on the scales of $(50 – 125)$ kpc, i.e. one order less than the group turn-over radius $R_o$.

As it is seen from Figure 2, centroids of the nearby groups have a low velocity dispersion with respect to the Hubble flow that is an independent evidence of the low mean density of matter in the Local volume (Governato et al. 1997). The principal galaxies in nearby groups (shown by crosses in Figure 2) have small peculiar velocities too. Only in the M 81 group do we find a significant peculiar velocity of the main member. (The situation in the Maffei group is complicated by heavy Galactic extinction, as well as confusion of HI emission from the group members with the Galactic HI emission). An apparent reason of the high peculiar velocity of the M 81 is the presence nearby M 81 of another bright galaxy, M 82, which has a peculiar velocity of opposite sign (see Table 3). Moreover, the peculiar velocities of M 81 and M 82 are inversly proportional to their luminosities. Consequently, the galaxies M 81 and M 82 are moving in the group as heavy bodies driven by the law of conservation of motion, rather than as test particles inside the common smooth potential well.

Supposing the dark matter in groups follows tightly the luminous matter, we can estimate the total contribution of groups to the mean density of matter. Based on the average weighted values: $<M_{\text{vir}}/L_B> = 31$, $<M_{\text{orb}}/L_B> = 34$, and $<M_{t}/L_B> = 21$ in solar units, we derive the total contribution of groups of galaxies to the mean density of matter to be $(0.03 – 0.04)$ in critical density units.

Recently, Guzik & Seljak (2002) and Hoekstra et al. (2004) determined parameters of dark halos for field galaxies and members of loose groups from weak lensing in the Sloan DSS and in the Red-Sequence Cluster Survey. For a galaxy with the mean luminosity of $L_B = 2 \times 10^{10} L_{\odot} (H_o = 72$ km s$^{-1}$ Mpc$^{-1}$) they derived a characteristic ratio $M/L_B = 41 M_{\odot}/L_{\odot}$ on a scale of $\sim 250$ kpc (after correction for internal extinction). This independent result agrees well with our data.

Thus, we may conclude that groups and clusters of galaxies produce approximately the same contribution to the mean density of matter. Their combined contribution is about $0.06 – 0.08$ in the units of critical density or about $(1/5 – 1/3)$ with respect to $\Omega_m = 0.27$. To avoid a contradiction with the global matter density $\Omega_m = 0.27$, derived from the WMAP, we need to assume the existence of another (non-baryonic) component of dark matter with the mean density $\Omega_{dm2} \simeq 0.20$. The DM2-component may be distributed in space either homogeneously like a dark cosmic “ocean”, or consists of many low mass halos without gas and stars, as assumed by Tully et al. (2002) and Tully (2004). Obviously, the presence of the DM2-component does not significantly affect the kinematics of even loose groups, because it contributes a small fraction (about 10% within $R_o = 1$ Mpc and about 0.1% within $R_{vir} = 0.2$ Mpc) into the integrated mass of groups.

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REFERENCES

Bahcall N.A., Cen R., Dave R., Ostriker J.P., Yu Q., 2000, ApJ, 541, 1
Blanton, M.R., Hogg, D.W., Brinkmann, J. et al. 2003, ApJ, 592, 819
Côté, Mateo M., Sargent W.L.W., Olszewski E.W., 2000, ApJ, 537, L91
EkholmT., Baryshev Y., Teerikorpi P., et al. 2001, A&A, 368, L17
Evans N.W., Wilkinson M.I., Guhathakurta P., Grebel E.K., Vogt S.S., 2000, ApJ 540, L9
Evans N.W., Wilkinson M.I., 2000, MNRAS 316, 929
Governato F., Moore B., Cen R., et al. 1997, New Astronomy, 2, 91
Guzik J., Seljak U., 2002, MNRAS, 335, 311
Huchra J.P., Geller M.J., 1982, ApJ, 257, 423
Hoekstra H., Yee H.K., Gladders M.D., 2004, ApJ, 606, 67
Ibata R., Chapman S., Ferguson A.M., et al. 2004, MNRAS, 351, 117
Jerjen H., Freeman K.C., Binggeli B., 1998, AJ, 116, 2873
Karachentsev, I.D., Karachentseva, V.E., Huchtmeier W.K., Makarov D.I., 2004, AJ, 127, 2031
Karachentsev, I.D., Karachentseva, V.E. 2004, Astron. Zh., 81, 298
Karachentsev, I.D., Karachentseva, V.E. 2002, ASP Conference Series, Vol. 284, p. 325
Karachentsev, I.D., Sharina, M.E., Dolphin, A.E. et al. 2003a, A&A, 398, 467
Karachentsev, I.D., Makarov, D.I., Sharina, M.E. et al. 2003b, A&A, 398, 479
Karachentsev, I.D., Grebel, E.K., Sharina, M.E. et al. 2003c, A&A, 404, 93
Karachentsev, I.D., Sharina, M.E., Dolphin, A.E., & Grebel, E.K. 2003d, A&A, 408, 111
Karachentsev, I.D., Dolphin, A.E., Geisler, D. et al. 2002a, A&A, 383, 125
Karachentsev, I.D., Sharina, M.E., Dolphin, A.E. et al. 2002b, A&A, 385, 21
Karachentsev, I.D., Sharina, M.E., Makarov, D.I. et al. 2002c, A&A, 389, 812
Karachentsev, I.D. & Makarov, D.I. 2001, Afz, 44, 5.
Karachentsev, I.D. & Makarov, D.I. 1996, Lett. to Astron.Zh., 22, 510
Karachentseva V.E., Karachentsev, I.D., 1998, A&AS, 127, 409
Karachentseva, V.E., & Karachentsev, I. D. 2000, A&AS, 146, 359
Karachentseva V.E., Sharina M.E., 1987, The Catalogue of Low Surface Brightness Dwarf Galaxies, Publ. Spec. Astroph. Obs. 57, 1
Kilborn V.A., et al. 2002, AJ, 124, 690
Liske, J., Lemon, D.J., Driver, S.P. et al. 2003, MNRAS, 344, 397
Lynden-Bell D., 1981, Observatory, 101, 111
Makarov D.I., Karachentsev I.D., 2000, in IAU Coll. 174, “Small Galaxy Groups”, eds. M. Valtonen & C. Flynn, 40
Sandage A., 1986, ApJ, 307, 1
Schlegel, D.J., Finkbeiner, D.P., & Davis, M., 1998, ApJ, 500, 525.
Shandarin S.F., 2004, (astro-ph/0405303)
Spergel D.N., Verde L., Peiris H.V. et al. 2003, ApJS, 148, 175
Tully, R.B., 1987, ApJ, 321, 280
Tully, R.B., Somerville R.S., Trentham N., Verheijen M.A., 2002, ApJ, 569, 573
Tully, R.B., 2004, (astro-ph/0312441)
vanden Bergh, S. 2000, The galaxies of the Local Group, Cambridge Univ. Press
Zucker D.B., Kniazev A.Y., Bell E.F., et al. 2004 (astro-ph/0404268)

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Fig. 1.— The total mass estimates derived from the zero-velocity surface at $R_o$ (vertical) versus the virial/orbital masses for the nearest galaxy complexes: Milky Way/M31 (the Local Group), M81/NGC2403, IC342/Maffei, CenA/M83. Two regions that are likely unbound: the Canes Venatici I cloud and the Sculptor filament are shown by the dotted boxes.

Fig. 2.— The Hubble diagram for the centroids of the nearest groups. The distances and radial velocities are shown with respect to the Local Group centroid. The line corresponds to the Hubble relation with $H_o = 72$ km s$^{-1}$ Mpc$^{-1}$ and a LG zero-velocity surface at 0.95 Mpc. The brightest members of the groups are indicated by crosses.
Table 1
The Milky Way group.

| Name        | Ty | $V_{MW}$ km s$^{-1}$ | $V_{LG}$ km s$^{-1}$ | $M_B$ mag  | $D$ Mpc | $\Theta$ |
|-------------|----|----------------------|----------------------|------------|---------|----------|
| Milky Way   | 4  | 0                    | -88                  | -20.80     | 0.01 cep | 2.5      |
| Sgr dSph    | -3 | 171                  | 161                  | -12.67     | 0.024 rgb | 5.6      |
| LMC         | 9  | 84                   | 28                   | -17.93     | 0.050 cep | 3.6      |
| SMC         | 9  | 17                   | -22                  | -16.35     | 0.063 cep | 3.5      |
| Ursa Min    | -3 | -85                  | -44                  | -7.13      | 0.063 rgb | 3.3      |
| Draco       | -3 | -98                  | -48                  | -8.74      | 0.079 rgb | 3.0      |
| Sex dSph    | -3 | 74                   | 8                    | -7.98      | 0.086 rgb | 2.8      |
| Sculptor    | -3 | 77                   | 96                   | -9.77      | 0.088 rgb | 2.8      |
| Carina      | -3 | 7                    | -53                  | -8.97      | 0.10 rgb  | 2.7      |
| Fornax      | -3 | -36                  | -32                  | -11.50     | 0.14 rgb  | 2.3      |
| Leo II      | -3 | 22                   | -18                  | -9.23      | 0.21 rgb  | 1.7      |
| Leo I       | -3 | 177                  | 128                  | -10.97     | 0.25 rgb  | 1.5      |
| Phoenix     | -1 | -103                 | -106                 | -10.22     | 0.44 rgb  | 0.8      |
| NGC 6822    | 10 | 44                   | 64                   | -15.22     | 0.50 cep  | 0.6      |
| Leo A       | 10 | -15                  | -40                  | -11.36     | 0.69 rgb  | 0.2      |
| Tucana      | -2 | 35                   | 9                    | -9.16      | 0.88 rgb  | -0.1     |
| SagDIG      | 10 | 9                    | 23                   | -11.49     | 1.04 rgb  | -0.3     |
| Sex A       | 10 | 163                  | 94                   | -13.95     | 1.32 cep  | -0.6     |
| Sex B       | 10 | 168                  | 111                  | -13.96     | 1.36 rgb  | -0.7     |
| Name         | Type | $V_{LG}$ km s$^{-1}$ | $M_B$ mag | $D$ Mpc | $\theta$ deg | $\Theta$ | 
|--------------|------|---------------------|-----------|---------|---------------|----------|
| M 31         | 3    | −35                 | −21.58    | 0.77 cep| 0.0           | 4.6      |
| NGC 221=M 32 | −5   | 121                 | −15.96    | 0.77 rgb| 0.40          | 6.8      |
| NGC 205      | −5   | 24                  | −16.15    | 0.83 rgb| 0.68          | 3.7      |
| And IX       | −3   | −                    | −7.5      | 0.79 rgb| 2.60          | 3.8      |
| And I        | −3   | −120                | −10.87    | 0.81 rgb| 3.31          | 3.7      |
| And III      | −3   | −92                 | −9.30     | 0.76 rgb| 4.98          | 3.5      |
| NGC 185      | −3   | 73                  | −14.76    | 0.62 rgb| 7.10          | 2.3      |
| NGC 147      | −3   | 85                  | −14.79    | 0.76 rgb| 7.43          | 3.0      |
| And V        | −3   | −143                | −8.41     | 0.81 rgb| 8.03          | 2.8      |
| And II       | −3   | 46                  | −9.33     | 0.68 rgb| 10.31         | 2.4      |
| M 33         | 5    | 36                  | −18.87    | 0.85 cep| 14.72         | 2.0      |
| Cas dSph     | −3   | −5                  | −11.67    | 0.79 rgb| 16.17         | 2.0      |
| IC 10        | 10   | −60                 | −15.57    | 0.66 cep| 18.42         | 1.8      |
| Peg dSph     | −3   | −94                 | −10.80    | 0.82 cep| 19.77         | 1.7      |
| LGS 3        | −1   | −74                 | −7.96     | 0.62 rgb| 19.87         | 1.7      |
| Pegasus      | 10   | 60                  | −11.47    | 0.76 rgb| 31.02         | 1.2      |
| IC 1613      | 10   | −89                 | −14.51    | 0.73 cep| 39.37         | 0.9      |
| Cetus        | −2   | −                    | −10.18    | 0.78 rgb| 52.4          | 0.5      |
| WLM          | 9    | −10                 | −13.59    | 0.92 rgb| 57.5          | 0.3      |
| DDO 210      | 10   | 13                  | −11.09    | 0.94 rgb| 76.6          | −0.1     |
| KKH 98       | 10   | 151                 | −10.78    | 2.45 rgb| 11.23         | −0.7     |
| KKR 25       | 10   | 68                  | −9.94     | 1.86 rgb| 74.3          | −0.7     |
| KK 230       | 10   | 126                 | −8.55     | 1.90 rgb| 101.2         | −1.0     |
| Name     | Ty | $V_{LG}$  | $R_p$ | $M_B$ | $D$ | $\Theta$ | Note       |
|----------|----|-----------|-------|-------|-----|----------|------------|
|          |    | km s$^{-1}$ | kpc   |       | Mag | Mpc      |            |
| M 81     | 3  | 107       | 0     | -21.06| 3.63| cep 2.2  |            |
| Ho IX    | 10 | 188       | 11    | -13.68| 3.7 | mem 3.3  |            |
| BK3N     | 10 | 101       | 11    | -9.59 | 4.02| rgb 1.0  |            |
| A0952    | 10 | 243       | 18    | -11.51| 3.87| rgb 1.9  | MD= N3077 |
| KDG 61   | -1 | 23        | 33    | -12.85| 3.60| rgb 3.9  |            |
| M 82     | 8  | 347       | 39    | -19.63| 3.53| rgb 2.7  |            |
| NGC 3077 | 10 | 153       | 49    | -17.76| 3.82| rgb 1.9  |            |
| FM1      | -3 | -         | 62    | -10.48| 3.42| rgb 1.8  | MD= M82   |
| BK5N     | -3 | -         | 73    | -10.61| 3.78| rgb 2.4  | MD= N3077 |
| IKN      | -3 | -         | 84    | -11.44| 3.7 | mem 2.7  |            |
| NGC 2976 | 5  | 139       | 87    | -17.10| 3.56| rgb 2.7  |            |
| KDG 64   | -3 | -         | 103   | -12.57| 3.7 | rgb 2.5  |            |
| KK 77    | -3 | -         | 104   | -12.03| 3.48| rgb 2.0  |            |
| F8D1     | -3 | -         | 121   | -12.59| 3.77| rgb 2.0  |            |
| HIJASS   | 13 | 187       | 147   | -7.9  | 3.7 | mem 2.2  |            |
| Ho I     | 10 | 291       | 156   | -14.49| 3.84| rgb 1.5  |            |
| KDG 63   | -3 | 0         | 169   | -12.12| 3.50| rgb 1.8  |            |
| HS 117   | 10 | 116       | 190   | -11.83| 3.7 | mem 1.9  |            |
| IC 2574  | 9  | 197       | 193   | -17.46| 4.02| rgb 0.9  |            |
| DDO 78   | -3 | 191       | 201   | -12.17| 3.7 | rgb 1.8  |            |
| DDO 82   | 9  | 207       | 214   | -14.63| 4.00| rgb 0.9  |            |
| BK6N     | -3 | -         | 304   | -11.08| 3.85| rgb 1.1  |            |
| KDG 73   | 10 | 263       | 321   | -10.83| 3.7 | rgb 1.3  |            |
| KKH 57   | -3 | -         | 373   | -10.19| 3.93| rgb 0.7  |            |
| DDO 53   | 10 | 151       | 519   | -13.37| 3.56| rgb 0.7  |            |
| DDO 52   | 10 | 268       | 506   | -11.49| 3.55| rgb 0.7  |            |
| Ho II    | 10 | 311       | 530   | -16.72| 3.39| rgb 0.6  |            |
| UGC 4483 | 10 | 304       | 436   | -12.73| 3.21| rgb 0.5  |            |
| NGC 2403 | 6  | 268       | 854   | -19.29| 3.30| cep 0.0  |            |
| UGC 6456 | 10 | 89        | 799   | -14.03| 4.34| rgb -0.3 |            |
| NGC 4236 | 8  | 160       | 776   | -18.59| 4.45| rgb -0.4 |            |
| DDO 44   | -3 | -         | 833   | -12.07| 3.19| rgb 1.7  | MD=N2403  |
| NGC 2366 | 10 | 253       | 809   | -16.02| 3.19| rgb 1.0  | MD=N2403  |
| UGC 7242 | 10 | 213       | 840   | -13.65| 4.3 | mem 0.4  | MD=N4236  |
| DDO 165  | 10 | 196       | 1075  | -15.09| 4.57| rgb 0.0  | MD=N4236  |
### Table 4
#### The Centaurus A Group

| Name            | Ty | $V_{LG}$ | $R_p$ | $M_B$ | $D$ | $\Theta$ | Note       |
|-----------------|----|----------|-------|-------|-----|---------|------------|
| NGC 5128        | −2 | 301      | 0     | −20.77| 3.66| rgb     | 0.6 MD=N4945 |
| Kks 55          | −3 | −42      | −9.91 | 3.6   | mem | 3.1     |            |
| KK 197          | −3 | −50      | −12.76| 3.6   | mem | 3.0     |            |
| ESO 324-024     | 10 | 270      | 102   | −15.45| 3.73| rgb     | 2.4        |
| KK 196          | 10 | 490      | 138   | −12.00| 3.6 | mem     | 2.2        |
| NGC 5237        | −3 | 131      | 143   | −15.00| 3.6 | mem     | 2.1        |
| KK 203          | −3 | −150     | −10.22| 3.6   | mem | 2.1     |            |
| KK 189          | −3 | −167     | −10.52| 3.6   | mem | 2.0     |            |
| ESO 269-66,KK 190 | −5 | 528      | 184   | −13.56| 3.54| sbf     | 1.7        |
| Kks 57          | −3 | −190     | −10.07| 3.6   | mem | 1.8     |            |
| KK 213          | −3 | −214     | −9.72 | 3.6   | mem | 1.7     |            |
| KK 211          | −5 | −235     | −11.93| 3.58  | rgb | 1.5     |            |
| ESO 325-011     | 10 | 307      | 242   | −14.05| 3.40| rgb     | 1.1        |
| KK 217          | −3 | −291     | −10.87| 3.84  | rgb | 1.1     |            |
| ESO 269-058     | 10 | 142      | 305   | −14.95| 3.6 | mem     | 1.9 MD=N4945 |
| Kks 53,Cen7     | −3 | −312     | −10.86| 3.6   | mem | 1.2     |            |
| ESO 269-37,KK 179 | −3 | −334     | −12.02| 3.48  | rgb | 1.6     | MD=N4945   |
| NGC 5206        | −3 | 322      | 342   | −16.66| 3.6 | mem     | 1.1        |
| Cen6,KK 182     | 10 | 360      | 350   | −11.89| 3.6 | mem     | 1.2        |
| KK 221          | −3 | −364     | −10.60| 3.98  | rgb | 0.6     |            |
| CenN            | −3 | −384     | −10.89| 3.6   | mem | 0.9     |            |
| HIPASS 1351     | 10 | 292      | 388   | −10.90| 3.6 | mem     | 0.9        |
| NGC 5102        | 1  | 230      | 410   | −18.08| 3.40| rgb     | 0.7        |
| HIPASS 1348     | 10 | 347      | 426   | −11.21| 3.6 | mem     | 0.8        |
| NGC 4945        | 6  | 296      | 468   | −20.51| 3.6 | mem     | 0.7        |
| Kks 51          | −3 | −476     | −11.46| 3.6   | mem | 0.7     |            |
| Kks 58          | −3 | −492     | −10.64| 3.6   | mem | 0.6     |            |
| ESO 384-016     | 10 | 350      | 624   | −13.06| 3.72| sbf     | 0.3        |
| ESO 219-010     | −3 | −557     | −12.70| 4.28  | sbf | 0.1     | MD=N4945   |
| PGC 51659       | 10 | 171      | 736   | −11.83| 3.58| rgb     | 0.1        |
| ESO 321-014     | 10 | 337      | 914   | −12.70| 3.19| rgb     | −0.3       |
### Table 5
The M83 group

| Name          | Ty | $V_{LG}$ km s$^{-1}$ | $R_p$ kpc | $M_B$ mag | $D$ Mpc | $\Theta$ | Note     |
|---------------|----|----------------------|-----------|-----------|---------|----------|----------|
| NGC 5236, M 83 | 5  | 304                  | 0         | -20.43    | 4.47 cep| 0.8      | MD=N5264 |
| KK 208        | -3 | -25                  | -14.24    | 4.68 rgb  | 2       |           |
| PGC 47885     | 10 | 360                  | 40        | -12.98    | 5.0 h   | 0.4      |          |
| ESO 444-078   | 10 | 363                  | 51        | -13.01    | 4.6 mem | 2.1      |          |
| NGC 5264      | 10 | 268                  | 80        | -15.90    | 4.53 rgb| 2.6      |          |
| IC 4316       | 10 | 382                  | 95        | -13.90    | 4.41 rgb| 2.4      |          |
| ESO 444-084   | 10 | 380                  | 145       | -13.56    | 4.61 rgb| 1.7      |          |
| NGC 5253      | 8  | 190                  | 154       | -17.38    | 4.00 cep| 0.5      |          |
| KK 218        | -3 | -167                 | -10.97    | 4.6 mem   | 1.6      |          |
| IC 4247       | 10 | 195                  | 181       | -14.18    | 4.6 mem | 1.5      |          |
| KK 200        | 9  | 264                  | 230       | -11.96    | 4.63 rgb| 1.2      |          |
| DEEP 1337-33  | 10 | 371                  | 279       | -11.18    | 4.51 rgb| 1.2      |          |
| KKs 54        | -3 | -308                 | -10.47    | 4.6 mem   | 1.0      |          |
| KK 198        | -3 | -379                 | -10.96    | 4.6 mem   | 0.8      |          |
| KK 195        | 10 | 338                  | 302       | -11.76    | 5.22 rgb| -0.2     |          |
| ESO 381-020   | 10 | 332                  | 911       | -14.15    | 4.6 h   | -0.3     |          |
| HIPASS 1337   | 10 | 258                  | 792       | -12.27    | 4.90 rgb| -0.3     |          |
| NGC 5408      | 10 | 288                  | 1002      | -16.50    | 4.81 rgb| -0.5     |          |
| ESO 381-018   | 10 | 353                  | 990       | -13.00    | 4.9 h   | -0.6     |          |

### Table 6
The IC 342 group

| Name         | Ty | $V_{LG}$ km s$^{-1}$ | $R_p$ kpc | $M_B$ mag | $D$ Mpc | $\Theta$ |
|--------------|----|----------------------|-----------|-----------|---------|----------|
| IC 342       | 5  | 245                  | 0         | -20.69    | 3.28 cep| -0.1     |
| KK 35        | 10 | 149                  | 15        | -14.30    | 3.16 rgb| 2.4      |
| UA 86        | 8  | 275                  | 91        | -18.06    | 3.12 rgb| 1.9      |
| NGC 1560     | 8  | 171                  | 311       | -16.87    | 3.45 rgb| 1.0      |
| CamB         | 10 | 266                  | 370       | -11.85    | 3.34 rgb| 1.0      |
| CamA         | 10 | 164                  | 325       | -14.06    | 3.93 rgb| 0.1      |
| Cas1         | 10 | 283                  | 529       | -16.70    | 3.3 mem | 0.5      |
| UGCA 105     | 9  | 279                  | 615       | -16.81    | 3.15 rgb| 0.3      |
| KKH 37       | 10 | 204                  | 952       | -11.55    | 3.34 rgb| -0.3     |
Table 7
The Maffei group

| Name   | Ty | $V_{LG}$ | $R_p$ | $M_B$ | $D$ | $\Theta$ |
|--------|----|----------|-------|-------|-----|---------|
|        | km s$^{-1}$ | kpc |       |       | Mpc |         |
| Maffei 2 | 4  | 212     | 0     | -20.15 | 2.8 | 1.4     |
| Maffei 1 | -3 | 246     | 36    | -18.97 | 3.01| 1.7     |
| MB 1    | 7  | 421     | 49    | -14.81 | 3.0 | 1.7     |
| MB 3    | 10 | 280     | 74    | -13.65 | 3.0 | 1.6     |
| Dwing 2 | 10 | 316     | 88    | -14.55 | 3.0 | 1.6     |
| Dwing 1 | 3  | 333     | 107   | -18.78 | 2.8 | 2.5     |
| KKH 12  | 10 | 303     | 146   | -13.03 | 3.0 | 1.4     |
| KKH 11  | 10 | 308     | 225   | -13.35 | 3.0 | 1.0     |
| KKH 6   | 10 | 270     | 630   | -12.42 | 3.8 | -0.8    |

Table 8
The Sculptor filament

| Name       | Ty | $V_{LG}$ | $R_p$ | $M_B$ | $D$ | $\Theta$ |
|------------|----|----------|-------|-------|-----|---------|
|            | km s$^{-1}$ | kpc |       |       | Mpc |         |
| NGC 253    | 5  | 274     | 0     | -21.37 | 3.94| 0.3     |
| DDO 6      | 10 | 348     | 287   | -12.50 | 3.34| 0.5     |
| NGC 247    | 7  | 215     | 302   | -18.81 | 4.09| 1.3     |
| Sc 22      | -3 | -       | 361   | -10.45 | 4.21| 0.9     |
| ESO 540-032| -3 | -       | 362   | -11.32 | 3.42| 0.6     |
| KDG 2      | -1 | -       | 482   | -11.39 | 3.40| 0.4     |
| NGC 7793   | 7  | 252     | 892   | -18.53 | 3.91| 0.1     |
| DDO 226    | 10 | 408     | 281   | -14.17 | 4.92| -0.1    |
| NGC 625    | 9  | 335     | 1292  | -16.53 | 4.07| -0.4    |
| NGC 59     | -3 | 431     | 570   | -15.74 | 5.30| -0.6    |
| ESO 245-05 | 9  | 308     | 1480  | -15.59 | 4.43| -0.7    |
### Table 9
**The Canes Venatici I cloud**

| Name            | Ty | $V_{LG}$ (km s$^{-1}$) | $R_p$ (kpc) | $M_B$ (mag) | $D$ (Mpc) | $\Theta$ |
|-----------------|----|------------------------|-------------|-------------|-----------|----------|
| NFC 4736,M 94   | 2  | 353                    | 0           | -19.83      | 4.66 rgb  | -0.5     |
| KK 160          | 10 | 346                    | 205         | -11.52      | 4.8 h     | 1.0      |
| IC 3687         | 10 | 385                    | 240         | -14.64      | 4.57 rgb  | 1.1      |
| IC 4182         | 9  | 356                    | 340         | -16.40      | 4.70 cep  | 0.6      |
| NGC 4449        | 9  | 249                    | 367         | -18.27      | 4.21 rgb  | 0.0      |
| DDO 126         | 10 | 231                    | 435         | -14.38      | 4.87 rgb  | 0.1      |
| KK 166          | -3 | -                      | 440         | -10.82      | 4.74 rgb  | 0.3      |
| DDO 168         | 10 | 273                    | 490         | -15.28      | 4.33 rgb  | 0.0      |
| NGC 4244        | 6  | 255                    | 560         | -18.60      | 4.49 rgb  | 0.0      |
| NGC 5229        | 7  | 460                    | 735         | -14.60      | 5.1 bs    | -0.6     |
### Table 10
Basic properties of the nearest galaxy groups.

| Parameter           | M.Way | M31  | M81  | CenA | M83  | IC342 | Maffei | Sc   | CVnI |
|---------------------|-------|------|------|------|------|-------|--------|------|------|
| $D_{MW}$, Mpc       | 0.01  | 0.77 | 3.63 | 3.66 | 4.56 | 3.28  | 3.01   | 3.94 | 4.09 |
| $D_{LG}$, Mpc       | 0.43  | 0.34 | 3.47 | 4.10 | 4.98 | 2.94  | 2.67   | 3.79 | 4.17 |
| $SGZ$, Mpc          | 0.00  | 0.07 | 0.04 | -0.33| 0.08 | 0.02  | 0.08   | -0.34| 0.77 |
| $N_{tot}$           | 15    | 19   | 29   | 28   | 14   | 8     | 8      | 6    | 9    |
| $N_{E+Sph}$         | 10    | 13   | 11   | 18   | 4    | 0     | 1      | 3    | 1    |
| $Ty(1)$             | 4     | 3    | 3    | -2   | 5    | 5     | 4      | 5    | 2    |
| $M_B(1)$, mag       | -20.80| -21.58| -21.06| -20.77| -20.43| -20.69| -20.15| -21.37| -19.83|
| $V_m(1)$, km s$^{-1}$| 220  | 255  | 232  | 398  | 211  | 162   | 163    | 199  | 164  |
| $V_{LG}(1)$, km s$^{-1}$| -88  | -35  | 107  | 301  | 304  | 245   | 212    | 274  | 353  |
| $\langle V_{LG}\rangle$, km s$^{-1}$| -79  | -16  | 193  | 312  | 308  | 229   | 302    | 279  | 306  |
| $\sigma_v$, km s$^{-1}$| 76   | 77   | 91   | 105  | 71   | 54    | 59     | 54   | 56   |
| $\langle R_p \rangle$, kpc | 155  | 254  | 211  | 290  | 164  | 322   | 104    | 359  | 385  |
| $L_B, 10^{10}L_\odot$| 3.28 | 6.83 | 6.11 | 5.55 | 2.31 | 3.21  | 2.69   | 5.58 | 2.00 |
| $M_{vir}, 10^{10}M_\odot$| 93   | 57   | 117  | 489  | 109  | 57    | 65     | 332  | 267  |
| $M_{orb}, 10^{10}M_\odot$| 96   | 111  | 197  | 288  | 100  | 95    | 135    | 153  | 322  |
| $M_{vir}/L$         | 28    | 8    | 19   | 88   | 47   | 18    | 24     | 60   | 133  |
| $M_{orb}/L$         | 29    | 16   | 32   | 52   | 43   | 30    | 50     | 28   | 161  |
| $T_{cross}$, Gyr    | 2.1   | 3.3  | 2.3  | 2.8  | 2.3  | 5.9   | 1.8    | 6.6  | 6.9  |
Table 11

Total mass estimates for the neighboring galaxy groups.

| Parameter          | M.Way/M31 | M81/N2403 | CenA/M83 | IC342/Maff | Sculptor | CVn I |
|--------------------|-----------|-----------|----------|------------|----------|-------|
| $\Sigma M_{vir}, 10^{10} M_\odot$ | 103       | 117       | 598      | 122        | 332      | 267   |
| $\Sigma M_{orb}, 10^{10} M_\odot$  | 200       | 197       | 388      | 230        | 153      | 322   |
| $R_0, \text{ Mpc}$       | 0.94±.10  | 1.05±.07  | 1.26±.15 | 0.90±.10   | 0.70±.10 | 0.63±.10 |
| $M_t, 10^{10} M_\odot$   | 121±38    | 169±34    | 292±104  | 106±35     | 50±22    | 37±18 |
| $L_t, 10^{10} L_\odot$   | 10.1      | 6.1       | 7.9      | 5.8        | 5.6      | 2.0   |
| $M_t/L_B$              | 12        | 28        | 37       | 18         | 9        | 19    |
