Clusters and groups of galaxies in the 2dF galaxy redshift survey

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Abstract. We create a new catalogue of groups and clusters for the 2dF GRS final release sample. We show that the variable linking length friends-of-friends (FoF) algorithms used so far yield groups with sizes that grow systematically with distance from the observer, but FoF algorithms with a constant linking length are free from this fault. We apply the FoF algorithm with a constant linking length for the 2dF GRS, compare for each group its potential and kinetic energies and remove galaxies with excess random velocities. Our sample contains 7657 groups in the Northern part, and 10058 groups in the Southern part of the 2dF survey with membership $N_g \geq 2$. We analyze selection effects of the catalogue and compare our catalogue of groups with other recently published catalogues based on the 2dF GRS. We also estimate the total luminosities of our groups, correcting for group members fainter than the observational limit of the survey. The cluster catalogues are available at our web-site (http://www.aai.ee/~maret/2dgr.html).

Key words. cosmology: observations – cosmology: large-scale structure of the Universe; clusters of galaxies

1. Introduction

Clusters and groups of galaxies are the basic building blocks of the Universe. They have been used for a wide range of studies: properties of the large-scale structure, galaxy formation and evolution, environmental studies, studies of dark matter and others. The classical cluster catalogues by Abell (1958) and Abell, Corwin and Olowin (1989) were constructed by visual inspection of Palomar plates. Recently new deep catalogues of galaxies have been made available, which allow compilation of new catalogues of groups and clusters of galaxies. The first catalogue of the new generation of galaxy groups was the Las Campanas catalogue of groups by Tucker et al. (2000). The next steps in this field were due to publication of the SDSS (Sloan Digital Sky Survey) data releases (EDR, DR1, DR2, DR3) and the 2dF GRS (2 degree Field Galaxy Redshift Survey) data releases (100K, final). This inspired numerous research teams to work out more refined cluster finding algorithms and to compile catalogues of galaxy systems (de Propris et al. 2002a; Merchan & Zandivarez 2002, 2004; Bahcall et al. 2003; Lee et al. 2004; Eke et al. 2004; Einasto et al. 2004a). A large collection of groups of galaxies has been compiled on the basis of the digitized Palomar Observatory Sky Survey (DPOSS) by Gal et al. (2002, 2002) and Lopes et al. (2004). Intermediate redshift groups of the CNOC2 survey were studied by Carlberg et al. (2001). A recent study of groups of galaxies was carried out using DEEP2 galaxies (Gerke et al. 2004).

In recent years a number of new group finding algorithms and well known methods (sometimes modified) have been applied (Kim et al. 2002; Bahcall et al. 2003) to these catalogues of galaxies. New methods have been proposed for finding groups in 2D surveys, using colors of galaxies, as in the Cut and Enhance method (see, e.g. Goto et al. 2001). However, the friend-of-friend (FoF) method is the most frequently applied for redshift surveys. Kim et al. (2002) and Nichol (2004) have compared various cluster finding methods. The use of different methods means that the resulting catalogues of groups and clusters of galaxies are rather different, particularly for loose and poor groups. Recently Lopes et al. (2004) claimed to have obtained agreement between the two methods they applied (Adaptive Kernel and Voronoi Tessellation). However, even a quick inspection of all various group catalogues reveals both large differences between the lists of these groups, as well as of their properties. A short review of the problem is given by Yang et al. (2004).

In addition, in the case of rich clusters there are problems of substructure in many, if not in a majority of clusters (Burgett et al. 2004; Einasto et al. 2004a). Analysis of recent catalogues of groups and clusters of galaxies has led us to the conclusion that all the presently available catalogues have their problems. In particular, in the only publicly available carefully compiled catalogue of the 2dF GRS groups by Eke et al. (2004) that can be checked for systematics, the characteristic (rms) radii of groups depend on the distance from the observer (see below). As an example, this catalogue contains a number of rich clusters. The dimensions of these clusters in the catalogue appear to be much larger than expected from Abell counts. A closer inspection of these
cases demonstrates the existence of substructure outside the main body of these rich clusters (Einstasto et al. 2004). To improve the cluster catalogue we tried several cluster-finding algorithms. After a number of trials we finally selected a series of procedures discussed below.

The goal of the present paper is to present a new catalogue of groups and clusters based on the 2dF Galaxy Redshift Survey. We apply the simple and well-known friends-of-friends algorithm with a constant linking length. In addition we apply a cleaning procedure, based on the comparison of the potential and kinetic energies of tentative groups. The data used and the group-finding and cleaning algorithms are discussed in the next two sections of the paper. Section 4 describes the group catalogue. The catalogue is available at the website http://www.aai.ee/~maret/2dfgr.html. We also estimate luminosities of groups and clusters, this is described in Section 5. In the last section we discuss the selection effects in our catalogue and in the 2PIGG catalogue by Eke et al. We also compare our groups with groups found by several other investigators. We use the term “group” for all objects in our catalogue; these include also clusters of galaxies.

2. The Data

In this paper we have used the 2dF GRS final release (Colless et al. 2001, 2003) that contains 245591 galaxies. The survey consists of two main areas in the Northern and Southern hemispheres within the coordinate patches given in Table I. As the 2dF sample becomes very diluted at large distances, we restrict our sample by a limiting redshift \( z = 0.2 \). We also apply a lower limit \( z \geq 0.009 \), as at smaller redshifts the catalogue contains mostly unclassified objects of the Local Supercluster, and stars. We do not restrict our sample by additional magnitude limits. However, we use the magnitude limit masks, when we find the group luminosity functions and luminosity weights (Einstasto et al. 2004). Our sample contains 78067 galaxies in the Northern sky and 106328 in the Southern sky. However, both the Northern as well as the Southern areas of the 2dF GRS have rather serrated edges, which can create serious edge effects. We start from the original galaxy sample, but restrict later our analysis of groups by more smooth sample edges. The redshifts were corrected for the motion relative to CMB. For linear dimensions we use co-moving distances, computed for the matter and dark energy density parameters 0.3 and 0.7, respectively (see, e.g., Martinez & Saar 2003).

3. Cluster finding algorithms

To search for clusters, the friends-of-friends (FoF) algorithm is conventionally applied. This algorithm has two main versions, suggested by Zeldovich et al. (1982) and by Huchra & Geller (1982) (hereafter ZES and HG, respectively). These algorithms are essentially identical with one difference: ZES used a constant linking length to find neighbours, whereas HG applied a variable linking length \( k(r) \) depending on the observed volume density of galaxies \( \rho(r) \) (or the selection factor \( f(r) = \rho(r)/\rho(0) \)) at a distance \( r \) from the observer. Several types of scaling of the linking length(s) have been used; see a summary by Eke et al. (2004); these can be classified by the cluster models the authors have used, either consciously or unconsciously. The original Huchra & Geller scaling, \( l \sim f^{-1/2} \), corresponds to the real-space cluster analysis, where all distances between galaxies are diluted by the same factor. In real observations, we should differentiate between projected distances in the sky and radial velocity-space distances. The projected distances scale under dilution as \( l_{\text{sky}} \sim f^{-1/2} \). The sizes of observed clusters in velocity space (\( \Delta v/H \)) are usually about 10 times larger than their radial sizes. It means that all position information is practically lost in velocity space, and the linking length in this space should remain constant, or more exactly, scale by the usual Doppler broadening, \( l_{\text{v}} \sim (1 + z) \) (Harrison 1974); this effect is negligible for current redshift catalogues. The first authors to arrive at this conclusion were Nolthenius & White (1987), somewhat, their careful analysis has been forgotten lately. The situation is complicated yet by the luminosity-density correlation – brighter galaxies tend to be more clustered, and the FoF scaling length should be calibrated by galaxy brightness, also.

![Fig. 1. The rms sizes of groups of the 2dF GRS PIGG catalogue, compiled by Eke et al. (2004) as a function of the co-moving distance \( d \) (for the Northern sample; the Southern sample has a similar distribution).](image)

As the FoF scaling is rather complicated, all the resulting group catalogues should be checked on the presence of systematic trends. For the 2dFGRS, the only publicly available group catalogue is the 2PIGG catalogue of Eke et al. (2004). They stress that the FoF parameters should be chosen to guarantee that the group sizes should not change while diluted by selection. This is really an important requirement, otherwise our catalogue would consist of different objects, those nearby and those far away. Strangely, they do not check if their choice of the FoF scaling satisfies this requirement, although it is easy to do – their catalogue includes the rms sizes of the groups. We plot the rms sizes of the 2PIGG groups versus the group distance in Fig. 1; as we see, a considerable trend remains. We found a similar trend in a variable linking length FoF group catalogue based on the SDSS DR1 (Einstasto et al. 2004).
In order to study the effect of different FoF scalings, we generated two versions of the group catalogue for the 2dF GRS, one with a constant linking length, and another with a variable linking length \( l \sim f^{-1/3} \). We compared the distribution of galaxies in rich clusters using both versions of the catalogue, and the 2PIGG catalogue. We also included for comparison rich clusters by Abell (1958) and Abell et al. (1989) as standard clusters, obtained using constant metric radii for clusters. The redshift data for the ACO clusters were taken from the catalogue by Andernach & Tago (1998) and Andernach et al. (2004). We present in Fig. 2 two examples of this comparison. In the left panel of the figure we show the distribution of galaxies in the sky for the rich galaxy cluster Abell 933. In the 2PIGG catalogue (variable linking length), smaller clusters and a number of nearby galaxies join to the cluster. In our catalogue, in the case of constant linking length, the cluster includes only galaxies inside the Abell radius of \( 1.5 \, h^{-1} \) Mpc. More distant galaxies are found to form separate groups, which are less rich, and have smaller radii. As another example we present in the right panel of Fig. 2 the FoF groups for the 2dF GRS in the vicinity of the cluster Abell 1650. We see that in the case of a too high linking length the 2dF GRS group is more extended than the corresponding Abell cluster.

So, too high or increasing linking lengths cause considerable extension of the groups and clusters, mainly by including nearby filaments and surrounding smaller groups. This forces us to apply a constant linking length in the FoF method, along with an additional “cleaning” procedure, described below. In this case the mean virial radii and the mean projected diameters of groups are practically constant, see Fig. 3. This figure confirms also that when the virial radii are constant in the mean, then so are the maximum diameters; we did not check it directly for the 2PIGG groups.

In order to find the best linking lengths, we found the groups, using a number of different parameter values: \( \Delta V = 100 - 900 \, \text{km/s} \) and \( \Delta R = 0.2 - 1.0 \, h^{-1} \) Mpc, and chose finally the values presented in Table 1. These values of the FoF parameters correspond to the best behaviour of group sizes with distance in the 2dF GRS. Higher values for \( \Delta R \) lead to inclusion of galaxies from neighbouring groups and filaments. Lower values for \( \Delta V \) exclude the fastest members in intermediate richness groups.

In addition, we applied a clean-up procedure to remove from groups galaxies with too high peculiar velocities. The procedure follows the prescriptions proposed by Heinämäki et al. (2003), from comparison of simulations and the LCRS groups. The essence of the clean-up method is the comparison of the potential and kinetic energies of groups to iteratively reject unbound members. This cleaning criterion can be expressed as:

\[
(\sigma_V/V_0)^2 \geq N_g/(R_{vir} + R_0)
\]

where \( \sigma_V \) is the radial velocity dispersion, \( V_0 \) is a calibrating parameter, \( N_g \) is the number of group members, \( R_{vir} \) is an estimate of the projected virial radius, and \( R_0 \) is a constant which takes into account the difference between the spatial and projected radii and has a value of a typical galaxy size (galaxies

### Table 1. Data on the 2dF GRS samples and group finding parameters

| Sample  | RA    | DEC   | \( N_{gal} \) | \( N_{groups} \) | \( N_{single} \) | \( \Delta V \) | \( \Delta R \) | \( V_0 \) | \( R_0 \) | \( n_{iter} \) |
|---------|-------|-------|---------------|----------------|-----------------|--------------|--------------|--------|--------|-------------|
| 2dF GRS N | 140...230 | -7...+3 | 78067 | 7657 | 54604 | 750 | 0.3 | 50 | 0.03 | 3 |
| 2dF GRS S | 320...58 | -37.5...-23 | 106328 | 10058 | 75838 | 750 | 0.3 | 50 | 0.03 | 3 |
can’t be closer to each other than $R_0$). We know only the projected value for $R_{\text{vir}}$, and estimate the radial velocity dispersion from observations; therefore, the formula above has only statistical meaning and may be in error for any particular group.

The groups found by the FoF method were checked for this criterion and the rejected galaxies were checked for membership in the next step of iteration; this allows us to break unbound groups into bound subgroups. Rejection of the members for each particular group, which do not satisfy the energy criterion, starts from the most distant member from the group center in the velocity space and is iteratively carried out until the criterion is satisfied or the whole group is rejected. Then we start the procedure (FoF and the following clean-up) again for the galaxies which were rejected as group members in the previous iteration. We found that three such global iteration steps were enough, later steps yielded only bound groups and isolated galaxies.

Fig. 3 demonstrates that our method is free of distance trends: the group virial radii do not depend on redshift, in contrary to the 2PIGG groups by Eke et al., presented in Fig. 1. As we see in Fig. 3 the projected diameters of groups practically do not change with redshift, being constant in the mean. One can observe a scarcity of large systems after $d \approx 400 \, h^{-1} \, \text{Mpc}$.

This can be attributed to two effects: the decrease of the multiplicity of groups (see Fig. 8) and the drop of the total number of groups at that distance (see Fig. 7). At large distances only the brightest members of groups are visible, and it is well known that bright galaxies tend to concentrate toward the group centres. Due to the decrease of the number of groups statistic may play a role: the probability of observing very large (and very small) groups is low. This effect could also be partly caused by the presence of rich superclusters at both the 2dF GRS patches at the distances $200–400 \, h^{-1} \, \text{Mpc}$.

Fig. 4 illustrates the cleaning procedure, showing the rms velocity vs richness relation for the groups before and after the clean-up. We see that this procedure has excluded groups (mainly of low richness) which had too high velocity dispersion, and has broken up a few high-richness groups.

The number of obtained groups and the FoF parameters (for both equatorial slices) are given in Table 1.

4. Group catalogue

Our final catalogue includes 7657 Northern and 10058 Southern groups with richness $\geq 2$. Both of the group tables include the following columns for each group:

- $R_{\text{vir}}$ [$h^{-1} \, \text{Mpc}$]
- $d$ [$h^{-1} \, \text{Mpc}$]
- $R_{\text{size}}$ [$h^{-1} \, \text{Mpc}$]
- $\sigma_v$ [km/s]
- Group richness

Fig. 3. Sizes of our 2dF GRS groups, for a constant linking length. Left panel – the virial radius vs. distance, right panel – the maximum projected diameter vs. distance.

Fig. 4. Group rms velocities as a function of cluster richness for uncleaned (points) and cleaned (open circles) samples in the Northern (left panel) and the Southern patches (right panel).
The estimated total luminosity was calculated as follows (Einasto et al. 2002): the estimated total luminosity per one visible galaxy. This means that the luminosities of groups we have to find for all galaxies of the same absolute magnitude limits of the window.

The identification number is attached to groups by the group finder in the order the groups are found (independently of the system). Calculation of luminosities is described in the next section.

We also present (in an electronic form) a catalogue of all individual galaxies along with their group identification and the group richness, ordered by the group identification number, to facilitate search. The tables of galaxies end with a list of isolated galaxies (or small groups with only one bright galaxy within the observational window).

We used two sets of Schechter parameters to calculate the luminosity weights: $\alpha_1 = -1.21$, $M_1^{*} - 5 \log_{10} h = -19.66$, and $\alpha_2 = -1.28$, $M_2^{*} - 5 \log_{10} h = -20.07$. The first set was found by N02 for the whole 2dF galaxy sample, the second set by De Propris et al. (2002) for cluster galaxies. We calculated for each group the total observed and corrected luminosities, and the mean weight

$$ W_m = \frac{\sum L_{obs,i}}{\sum L_{obs,i}}, $$

where the subscript $i$ denotes values for individual observed galaxies in the group, and the sum includes all member galaxies of the system.

The mean weights for the groups of the 2dF GRS Northern subsample are plotted as a function of the distance from the observer. Weights corresponding to Schechter parameter set 1 are plotted by gray symbols, weights for parameter set 2 with black symbols.

Following Eke et al. (2003) we accepted $M_5 = 5.33$ in the $B_i$ photometric system. Further we have adopted the $k + e$-correction according to Norberg et al. (2002) as follows: morphological Type 1: $k + e = (2z + 2.8z^2)/(1 + 3.8z^3)$; Type 2: $k + e = (0.6z + 2.8z^2)/(1 + 19.6z^3)$; Type 3: $k + e = (z + 3.6z^2)/(1 + 16.6z^3)$; Type 4: $k + e = (1.6z + 3.2z^2)/(1 + 14.6z^3)$. The morphological types were defined as follows: Type 1: $\eta < -1.4$; Type 2: $-1.4 < \eta < 1.1$; Type 3: $1.1 \leq \eta < 3.5$; Type 4: $3.5 \leq \eta$, where $\eta$ is the spectral classification parameter, given in the 2dF GRS catalogue. For some galaxies with poor spectra the spectral type parameter $\eta$ is not determined; in these cases we applied the mean relation: $k + e = (z + 3.2z^2)/(1 + 20z^3)$ (N02).

Access to the data is available at http://www.aai.ee/~maret/2dfgr.html. Explanation of the table columns is given in the file 2dfgroups.readme.
a bit higher than unity at distance $d \sim 80 \ h^{-1} \text{Mpc}$, and increases both toward smaller and larger distance. The increase at small distances is due to the absence of very bright members of groups, which lie outside the observational window, and at large distance due to the absence of faint galaxies. The weights grow fast for very close groups and for groups farther away than about $400h^{-1} \text{Mpc}$. At these distances correction factors start to dominate and the luminosities of groups become uncertain.

We also see that at large distances the weights corresponding to the Schechter parameter set 1 are systematically higher than the weights of the set 2. This difference is due to the fact that the Schechter function, calculated for the whole galaxy sample, takes into account also the presence of groups which have no galaxies within the observational window (i.e., all galaxies of the group are too faint); the luminosity of these galaxies is tacitly added to the luminosity of visible groups (for a detailed discussion of this selection effect see Einasto et al. 2003b). The parameter set 2 was determined using only galaxies, which lie in visible groups and clusters; thus this set should yield unbiased values for weights and total luminosities. In the following we have used only this set of weights and luminosities.

In Fig. 6 we show the estimated total luminosities of groups as a function of distance. We produced also colour figures that visualize the luminosities of groups. These are too detailed to present here, and can be found at our web pages. These figures show that the brightest groups have corrected total luminosities, which are, in the mean, independent of distance. This shows that our calculation of total luminosities is correct.

### 6. Selection effects

The main selection effect in surveys like the 2dF GRS is caused by a fixed interval of apparent magnitudes, $m_1 \ldots m_2$, used in selection of galaxies for redshift measurements. This interval translates to an absolute magnitude interval, $M_1 \ldots M_2$, that depends on the distance from the observer $d$. This effect is well seen in Fig. 6 where the estimated total luminosities of our groups/clusters are shown as a function of the distance $d$. We see a well-defined lower luminosity limit of groups that increases with distance. This low-luminosity limit is due to the faint-end limit of the 2dF observations, $m_2 \approx 19.45$ in $b_j$.

This selection effect affects groups in several ways. First of all, in nearby space our group-finding algorithm finds faint as well bright groups, whereas at large distance only bright groups can be found. This is the effect shown in Fig. 6.

The primary consequence of this selection effect is the decrease of the volume density of groups at large distances. The mean volume density of groups in shells of fixed thickness as a function of distance is plotted in Fig. 7 separately for the Northern and Southern strip of the 2dF GRS. For comparison we give a similar distribution also for the groups of the Eke catalogue. We see that the spatial density decreases by a factor of about 1000 for the present catalogue. The Eke catalogue has greater depth and includes a number of very faint groups in the nearby volume; for this reason the spatial density interval is even larger, almost 5 orders of magnitude. This decrease must be taken into account in statistical analysis of catalogues, usually by selection functions. As the correction amplitudes are large, the results of statistical analysis of group catalogues can easily become correction-dominated.

The limited magnitude interval introduces one more selection effect: it decreases the number of galaxies seen in groups. The low-luminosity end of the observational window of absolute magnitudes shifts with increasing distance toward brighter magnitudes. As a result, faint members of groups fall outside the observational limit, and the multiplicity of the group decreases. In Fig. 8 we show the multiplicity of groups (the number of galaxies) as a function of distance from the observer, separately for Northern and Southern groups. A similar plot is given for the groups by Eke et al., for comparison. We see that rich groups are seen only up to a distance of about $300h^{-1} \text{Mpc}$, thereafter the mean multiplicity decreases considerably with distance. This selection effect must be accounted for in multiplicity analysis.

To illustrate the selection effect on cluster multiplicity, we made the following test. We selected in the nearby volume ($d < 100h^{-1} \text{Mpc}$) a number of groups with multiplicity $N_{gal} > 20$, shifted the groups progressively to larger distances, and calculated the multiplicity of the group, if it were located at this distance. As with increasing distance more and more fainter members of groups fall outside the observational window of apparent magnitudes, the multiplicity decreases with distance. The results of our calculations for ten groups are shown in Fig. 9. We see that the number of galaxies within the observational window decreases in logarithmic scale almost linearly. The slope of this power law depends on the luminosity function of galaxies in groups. Groups populated mainly with faint galaxies lose their members more rapidly than groups populated with brighter galaxies, as expected. The majority of groups selected for this test have at a certain distance only one visible galaxy left, that becomes also invisible if the distance increases further. At the largest distance only one group selected for this test is visible as a single galaxy, all other groups have become too faint to be detected within the visibility window of the 2dF GRS.

### 7. Discussion and conclusions

#### 7.1. Comparison to other studies

Here we compare various group catalogues obtained for the 2dF GRS. We have found five papers on groups, based on the 2dF GRS galaxies. The first attempt to study the 2dF GRS clusters of galaxies, based on well-known previous clusters, was done by De Propris et al. (2002a). However, as their catalogue starts from the known clusters (Abell 1958; Abell et al. 1989 APM; EDCC) and not from the 2dF GRS sample, we have not included it in our comparison of the 2dF GRS groups. Table 2 presents data for groups from various catalogues, based on the 2dF GRS.

Several studies have shown (see, e.g., Kim et al. 2002) that different methods give rather different groups for the SDSS sample. The same is true for the 2dF GRS groups. Although all four methods in Table 2 are FoF-based, the results are...
Fig. 6. The estimated total luminosities of clusters of galaxies of the 2dF at various distance from the observer. The left panel shows groups/clusters of the Northern section, the right panel of the Southern section.

Fig. 7. The spatial density of groups as a function of distance from the observer. The left panel shows data for the groups found in the present paper, the right panel for the 2PIGG groups.

Fig. 8. The multiplicity of groups as a function of distance from the observer. The left panel shows data for the groups found in the present paper, the right panel for the Eke groups.

markably different. In particular, Yang et al. (2004) applied a more elaborate group finder. They noted that the number of clusters they found corresponds to numbers obtained by Eke et al., concluding, however that their cluster finder is better than that used by Eke et al. Unfortunately, the groups by Yang et al. (2004) are not publicly available, and we cannot compare them with our groups.

Single galaxies can be considered as belonging to small groups or to halos represented by one observed galaxy. The fraction of galaxies in groups by Eke et al., Yang et al. and in this paper is 55, 60 and 30%, respectively (these are the
Table 2. Data on groups from catalogues based on the 2dF GRS

| Sample       | $N_{gal}$ | $N_g(n \geq 2)$ | $N_g(n \geq 4)$ | $z_{lim}$ | $m_{lim}$ | method                      | % in clusters | available |
|--------------|-----------|-----------------|-----------------|-----------|----------|-----------------------------|--------------|-----------|
| Merchan 2002 | 60000     | -               | 2209            | 0.25      | 19.45    | modified FoF                |              | no        |
| Eke 2004     | 191440    | 28877           | 7200            | 0.11 (median) | FoF with test mock | 55 % yes |                |
| Yang 2004    | 150715    | 11434           | 2471            | 0.2       | 19.45    | FoF modified + mock test    | 60 %         | no        |
| Tago 2004    | 184495    | 17715           | 3044            | 0.009 - 0.2 | FoF + clean-up | 30 % yes |                |

catalogues where the data are available). Different fractions of galaxies in groups (or the fractions of single galaxies) lead to the different number density of halos, as well as to different distributions of the halo occupation number. A very important problem of substructure was stressed and extensively studied by Burgett et al. (2004). Their conclusion is that most of the clusters have substructures which merge into a large cluster in a very long dynamical time scale. Therefore, we are faced with the problem, if we have to count a collection of different haloes in process of merging as one cluster or a number of sub-clusters. The large number of merging (sub)groups (and the existence of a large number of groups of low richness) is a justification for a large fraction of single galaxies in our results. Our group finder is tuned for more compact, and gravitationally bound groups – we applied a clean-up procedure to our groups that compares the potential and kinetic energies of groups, to obtain a statistically reasonable catalogue of bound groups; – we analyzed selection effects in group catalogues and compared of our group catalogue to the catalogue by Eke et al. (2004). we found that the catalogues differ for group densities, multiplicities and sizes. – we present our catalogue at our web page (http://www.aai.ee/~maret/2dfgr.html); we hope that it will serve as a basis for further studies of large-scale structure.

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Fig. 9. The number of galaxies in groups, shifted progressively to a larger distance $d$. Solid lines show the results for groups with intrinsically bright galaxies, dashed lines for groups with fainter member galaxies.

7.2. Conclusions

The main results of the present paper are following:

– we present a catalogue of groups and clusters of galaxies of the 2dF GRS final data release. We applied the FoF method with a constant linking length, in which case the properties of groups depend less on their redshift, than in the conventional case of a variable linking length;
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