The Dynamics of the cD Clusters Abell 119 and Abell 133

M.J. Way\textsuperscript{1}, H. Quintana\textsuperscript{2,3} and L. Infante

Department of Astronomy and Astrophysics, P. Universidad Catolica de Chile,
Casilla 104, Santiago 22, Chile
I: mway@newton.umsl.edu

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\textsuperscript{1}present address: Department of Physics and Astronomy, University of Missouri-St. Louis,
8001 Natural Bridge Rd., St. Louis, MO 63121-4499

\textsuperscript{2}Visiting Astronomer, Las Campanas Observatory of The Carnegie Institute of
Washington

\textsuperscript{3}1995 Presidential Chair in Science
ABSTRACT

A dynamical analysis of the structure of the clusters of galaxies Abell 119 and Abell 133 is presented, using new redshift data combined with existing data from the literature. We compare our results with those from the X-ray data for these clusters, and with those from radio data for the central cD galaxy in each cluster. A comparison of the mass estimate based on X-ray data and that obtained here after subgroups are eliminated shows them to be comparable. After the elimination of subgroups, 125 galaxy members in Abell 119 and 120 in Abell 133 give dispersions of 472 km s$^{-1}$ and 735 km s$^{-1}$ respectively. However, our dynamical analysis of the optical data shows little substructure in the velocity field of Abell 133, conflicting with what is seen in the Rosat X-ray map. Abell 119 seems to have multiple structures along the line of sight. We derive virial mass estimates of 3.05 $\times$ 10$^{14}$ M$_{\odot}$ for Abell 119 and 7.79 $\times$ 10$^{14}$ M$_{\odot}$ for Abell 133 within 1.5 h$^{-1}$Mpc, which agree well with the X-ray-derived masses within errors.

Subject headings: clusters: galaxies
1. Introduction

Regular, rich clusters of galaxies are the largest objects in the Universe likely to be bound and possibly relaxed. Their differing shapes, concentrations and populations are customarily interpreted as representing different stages in the gravitational evolution of the matter of the cluster. The most regular clusters usually have galaxies of type cD at their centers. The view that such clusters have reached stationary equilibrium is generally accepted. However, recent work has shown the presence of significant substructure in these clusters, challenging the virialization and relaxation hypothesis. To search for substructure one need not only look at the distribution of galaxies, but to analyze the gas profiles and inhomogeneities as revealed by the X-ray data and the dynamical information provided by the velocity field of the galaxies throughout the cluster.

The nearby cD clusters Abell 119 and Abell 133 are among the brightest sources in X-rays. As such, they were promising sources to be studied in depth in the optical and X-ray bands. Together with other clusters accessible to our southern programs, they were chosen to carry out a deeper velocity survey using multi-fiber spectrographs. Here we report velocities taken with the Las Campanas DuPont 100" telescope.

In Section II we discuss how the data were obtained. We then explain the data reduction in section III, and in IV we detail how velocity data from the literature compares with this paper's data, and how it was integrated to our data for analysis. The dynamical analysis is presented in section V, broken up into several subsections for Abell 119 and 133. Finally, section VI contains a discussion and the implications of our analysis.
2. Observations

The aim of our program was to obtain velocities for as many galaxies as possible over a reasonably wide field, within the observational allocation of time. We chose to survey areas of 1.5° x 1.5° centered on the cD galaxies, the field covered by 100" DuPont telescope fiber spectrograph. Lacking previous photometric data to select a magnitude limited sample, we measured the positions of galaxies clearly identified on the glass copies of the Palomar Sky Survey at ESO, Garching. The plates were searched by eye on the Optronics machine monitor following strips in declination. The final astrometric lists contained some 400 galaxies in each cluster and a number of stars used for guiding the fiber arrays. The positions were determined from astrometric solutions based on 25 SAO or Perth reference stars, using standard programs at ESO. Their relative accuracy is 0.3 arcsec rms. However, the external accuracy should be of order 2 arcsec. See figures 1a and 1b for plots of the x-y positions. Notice in figure 1b that the bottom of the plot is blank because the entire field of Abell 133 is close to the edge of the scanned Palomar plate. We could not use a second plate to obtain the rest of the velocities because the external positional error between plates was too high.

We used Shectman’s fiber spectrograph \cite{Shectman1985} mounted on the 100" telescope on the nights of 22-25 October 1990. The multi-fiber system consists of a plug plate at the focal plane to which 65 fibers are attached and run to a Boller and Chivens spectrograph coupled to a 2DFrutti detector (2DF). A 600 line mm$^{-1}$ grating blazed at 5000Å was set at an angle 9° 40', giving a wavelength coverage from $\sim$3800-6800Å. Normally, 50-55 fibers are used for objects. Ten sky fibers are set aside, spaced at intervals of one every 6 fibers along the spectrograph entrance, and positioned in a random pattern in the plug plate. The resulting 2DF image has a 1520 x 1024 pixel area, with a dispersion of $\sim$2.6Å pixel$^{-1}$ and a final resolution of $\sim$10Å. The fiber images are $\sim$8 pixels wide, and
exposure time were adjusted to be between 80 and 120 minutes, depending on the brightness of the selected galaxies for each exposure. The 2DF detector is a photon counting system where one can view the current exposure at any stage. In this way one can obtain the optimum exposure time for a field. A faintness limit of ∼17.5 magnitudes in R was reached. 150 spectra in each of Abell 133 and Abell 119 were obtained in this run. Quartz lamp exposures were used to correct for pixel to pixel variations of the detector. To properly illuminate the whole detector surface the grating angle was changed to several values on these exposures. As well, helium-neon comparison lamp exposures were taken off the wind-screen for wavelength calibration before and after each exposure. The 2DFrutti detector has a small dark current and no corrections were made for that effect.

3. Reductions

Velocity determinations were carried out using a cross-correlation technique and by identifying and fitting by eye line profiles. All reductions were performed inside of the IRAF(Tody 1993) environment. For a complete discussion of the reductions see Quintana et al. 1996(hereafter QRW96). That described below is a summary of the reductions. Due to the nature of the fiber+2DFrutti system typical S shaped distortions are inherent in this instrument. A sixth order spline3 curve was used to trace the S shaped spectra. The IRAF HYDRA package was used to extract the spectra, correct pixel to pixel variations via the dome flat, use a Fiber Transmission Table for appropriate sky subtraction and put the spectra on a linear in wavelength scale. The wavelength solutions for 20-30 points using a 5, 6, or 7 order Chebyshev typically yielded residual values less than 0.4 rms Å, where 1 pix ∼2.6Å. The ten sky spectra from each exposure were combined via a median filter and subtracted from each of the object spectra.
Two different methods were used to measure the redshift of the objects. For normal early type spectra the RVSAO \citep{Kurtz1991} cross-correlation algorithm supported inside IRAF was used. The algorithm used in RVSAO is described in \cite{Tonry1979} (hereafter TD79). A reliability factor was generated by RVSAO called the R value (see TD79 for details). Normally a low R value ($R \leq 4$) indicated a need to look at the spectra and try line by line Gaussian fitting (the second method). To utilize RVSAO template spectra with high signal to noise and well determined radial velocities were needed. Two of the four templates used in this paper were galaxy spectra taken with the fiber instrument, NGC 1407 and NGC 1426, another galaxy (NGC1700) was from the previous detector on the 2.5 meter at Las Campanas (Shectograph), and one was a synthetic template. The synthetic template was constructed from the excellent library of stellar spectra of \cite{Jacoby1984}. We used ratios of stellar light for the E0 galaxy NGC1374 from the synthesis studies of \cite{Pickles1985}. In the end it was found that the template which gave the lowest error value out of the four radial velocity cross-correlation templates mentioned above proved to have more consistent results. For non-early type spectra (i.e emission lines, E+A, etc.) a line by line Gaussian fit was used and the resulting velocities from each line fit were averaged.

Tables 1 (Abell 119) and 2 (Abell 133) give the velocity results, where column 1 shows the identification number, columns 2 and 3 give 1950.0 epoch positions, and columns 4, 5, 6, 7 and 8 give the individual velocity values, their errors ($1\sigma$), the corresponding TD79 R values or number of measured lines (mostly emission) if the R number was too low for a proper velocity determination, references, and the identification number from each reference. Columns 9 and 10 give the final adopted velocities, if averaged, and their respective one $\sigma$ errors.

Multiple measurements and integrated velocity values from the literature were
combined and are described in the next section. Where large discrepancies exist with values quoted in the literature, they have been eliminated as indicated in the comments. The individual velocities retained have been averaged and weighted by the corresponding quoted errors (combined in quadrature) for an estimate of the final error.

For a number of galaxies 2 spectra were measured. This allows a check on internal consistency. These velocities are listed for the corresponding galaxies in Tables 1 and 2. In Abell 133 there are six galaxies with two measurements which differ by values from 6 to 75 km s$^{-1}$, just within the errors, showing good internal consistency. In Abell 119 five galaxies have 2 fiber spectra with differences ranging from 7 to 117 km s$^{-1}$. The only galaxy not falling within the quadratically added errors was number 25370 where the difference was 117 km s$^{-1}$ which can be attributed to the low signal to noise in one of the spectra obtained.

4. Comparison

A zero point shift for references with several velocities in common can be used to bring the data to a common system. This has been applied before averaging weighted by the respective errors (see QRW96 for details). The first systematic determination of velocities in Abell 119 was done by Melnick & Quintana 1981 (hereafter MQ81), who published 23 velocities, with typical errors 100-250 km s$^{-1}$. For 19 galaxies a systematic shift was found between this paper (fibr) and MQ81 (figure 2a) of $\sim$45 ± 217 km s$^{-1}$ rms after applying a $\sigma$ clipping routine that rids one of those MQ81 velocities quoted with errors larger than 150 km s$^{-1}$ (with the exception of one). As noted in MQ81, errors larger than 150 km s$^{-1}$ denote very uncertain velocities, a fact borne out by the new measurements. It is also noted that the position of galaxy 10 in MQ81 is wrong (due to a re-numbering of galaxies in that paper). Fabricant et al. 1993 (hereafter FAB93) give values for 60 velocities. Of the FAB93 velocities 48 are in common with this paper's fiber data. In comparison with
FAB93 (see figure 2b) there is a systematic shift of $\sim$28 km s$^{-1}$ with an RMS of $\sim$76 km s$^{-1}$. For completeness, in Table 1 12 galaxies are included with velocities measured solely by FAB93. Several velocity measurements in Abell 119 are added from the papers of Zabludoff et al. 1993 (2 measurements), de Vaucouleurs et al. 1991 (4), Huchra et al. 1983 (1), Sandage 1978 (1), and Kinman & Hintzen 1981 (1). A comparison with the two velocities in common with Zabludoff et al. 1993 show a systematic shift of $5 \sim 45 \pm 86$ km s$^{-1}$ rms. In Abell 133 overlapping velocities were found in the papers of Merrifield & Kent 1989 (3), and de Vaucouleurs et al. 1991 (5). In Merrifield & Kent 1989 a shift of -134 km s$^{-1}$ $\pm$ 64 rms was found. Using the 9 velocities in common with Abell 133 and Abell 119 from de Vaucouleurs et al. 1991 a systematic shift of -34 km s$^{-1}$ $\pm$ 81 rms was found. All of the shifts above suggest that it is this paper’s data which is shifted by roughly 40 km s$^{-1}$ with respect to the literature.

5. Dynamical Analysis

5.1. Abell 119

5.1.1. 1D tests (velocity space)

Information from the 1D velocity distribution was obtained with ROSTAT, a program for robust estimation of velocity distributions based on the work of Beers et al. 1990 and kindly distributed by Tim Beers. ROSTAT was first used to calculate the robust estimators of location $C_{BI}$ (average) and scale $S_{BI}$ (dispersion) with 10000 bootstraps and with 90% confidence intervals (see Table 3). As a first order attempt to remove outlier galaxies in the velocity distribution a standard 3 $\sigma$ ($S_{BI}$) clipping of Yahil & Vidal 1977 was used. Consequently, all galaxies in Abell 119 closer than 11033 and further than 15609 km sec$^{-1}$ were eliminated. This 3$\sigma$ clipped data is taken as defining the cluster. Then the cluster data
is taken through a second ROSTAT run using those points within the velocity ranges above to utilize the shape estimators of skewness, kurtosis, tail and asymmetry. Their values are listed in Table 3. For a thorough discussion of these estimators see Bird & Beers 1993.

Of the 4 estimators only the robust estimator of asymmetry shows no strong deviation from a Gaussian distribution, but note that the robust estimators, asymmetry and tail, are normally much more conservative and will give fewer false positives for non-Gaussian distributions than the classical skewness and kurtosis. The high positive kurtosis (leptokurtic) value leads one to believe the tails are heavier than expected for a Gaussian. The large positive value of skewness implies a lack of values below $C_{BI}$ or that values on the positive side of $C_{BI}$ are more enhanced than a standard Gaussian distribution. The tail index points to a double exponential shape rather than Gaussian. Given these indicators of non-Gaussian behavior the KMM objective partitioning algorithm was used to search for multiple Gaussians in the velocity field. See Ashman et al. 1994 for a detailed discussion. Briefly, KMM fits a user-specified number of Gaussians to the velocity data and estimates the improvement of the multiple Gaussian fit versus a single Gaussian. The user first inputs an estimate of the positions of the multiple Gaussians. Using the velocity histogram (figure 3a) as a starting point two, three, four, and five Gaussians were fit to the data. For the three Gaussian fit, Gaussians were first estimated at 11900, 13200, and 14650 km sec$^{-1}$ from the velocity histogram. The program returned values of 11837, 13253 and 14718 km sec$^{-1}$ with a rejection of the single Gaussian model at a confidence level of 97.9%. This three Gaussian model implies that two smaller groups are projected or in-falling toward the main cluster body, one from the front and one from the back. In fact FAB93 detected the foreground group as having velocities less than 12000 km sec$^{-1}$, but miss the background group. In figure 4 the three groups are over plotted. *Group 1* is denoted by □ (11 members), *group 2* by • (125 members) and *group 3* by + (17 members). Further attempts to subdivide *group 2* using KMM were unsuccessful. Running ROSTAT on the 3 groups provides one
with further information. *Group 1* has a large negative skewness implying a distribution with depleted values above the mean velocity. *Group 3* is the reverse with positive skewness implying depleted values below the mean velocity. The kurtosis values for both are a little high implying heavy tails. The tail index for *group 1* has a CN(0.20,3) distribution shape according to Table 1 of [Bird & Beers 1993](#), where 20% of the points within a Gaussian width of 3 $\sigma$ are bad. In *group 3* the kurtosis value of 1.222 points to a double exponential distribution. This would lead one to believe that the groups are being pulled apart by the gravitational field of *group 2*, distorting their distributions.

A histogram of velocities for *group 2* is presented in figure 3b. All galaxies were within $3\sigma$ of each other and the results for $C_{BI}$, $S_{BI}$, skewness, kurtosis, asymmetry, and tail are shown in Table 3. The skewness and asymmetry indices imply a Gaussian distribution. The kurtosis index once again points to a tailed Gaussian distribution and the tail index implies that we have a normal distribution. Further analysis on *group 2* using 2D and 3D estimators demonstrate that these are probably false positive rejections of a Gaussian distribution, see following subsections.

### 5.1.2. cD velocity offset, $Z_{\text{score}}$

In relaxed clusters the cD galaxy should sit at the bottom of the potential well, thus they should be at the center of the velocity distribution ([Quintana & Lawrie 1982](#)), which is borne by $\sim70\%$ of cD clusters ([Bird 1994](#)). A significant cD galaxy velocity offset from the cluster mean (or the $Z_{\text{score}}$, [Gebhardt & Beers 1991](#)) may be an indicator of substructure. [Bird 1994](#) has shown that if one attempts to identify the cD galaxy’s host clump, using the methods in this paper to eliminate non-cluster members, that most cases of “speeding cDs” disappear.
In Table 4 the $Z_{score}$ values for the cluster and group 2 are presented. One can see that the $Z_{score}$ for group 2 is slightly larger than that for the cluster, but the $Z_{score}$ with bootstrapped errors bracket zero which would not indicate a significant velocity offset, implying that the Abell 119 cD is indeed sitting at the center of its host clump. The host clump being group 2, which has a qualitatively similar $Z_{score}$ value. It can be seen that the fore and background clumps might tend to balance out the $Z_{score}$ of the cluster because it is dependent solely on the measured 1-D radial velocities of galaxies.

5.1.3. 2D and 3D tests

To further test the cluster and group 2 data several 2 and 3 Dimensional substructure tests were used. The Lee statistic (Fitchett M.J. 1988) tests a 2D dataset for the presence of 2 equal sized groups versus 1. The 3D Dressler & Schectman 1988 $\Delta$ test, West & Bothun 1990 $\alpha$ test, and Bird 1994 $\epsilon$ test all look for clumping in the spatial and velocity data. The test results are presented in Table 4. The Lee statistic results for the cluster dataset imply a null result for the two group fit because of the low value of $L_{RAT}$ and a p value of 117 (where p less than 25 implies a statistically significant amount of substructure). On the other hand a plot of the Lee statistic distribution (figure 5a) can help to define an elongation axis, if any, of the 2D distribution. The highest point in figure 5a defines the elongation axis of the cluster to be $\phi_{max}=86.4^\circ$. Any multiple peaks seen in the Lee statistic plot may be an indicator of more complex structure, even given the low $L_{RAT}$, but there are no multiple peaks here. The Lee statistic applied to group 2 has a slightly higher value of $L_{RAT}$, but the p value still rejects any statistically significant substructure. The Lee statistic for group 2 plotted in figure 5b differs little from that of the cluster in figure 5a. The elongation axis $\phi_{max}=86.4^\circ$ seen in the cluster plot of 5a (the peak in 5a) has vanished.

In contrast all of the 3D tests (Table 4) report null for the substructure hypothesis in
the cluster data even though two in-falling clumps along the line of sight (LOS) were found using KMM, but tests done by Bird 1993 indicate that the 3D tests are insensitive to LOS mergers!

2D and 3D tests were also applied to group 2. Since the foreground and background groups were along the LOS of “the cluster” and are more or less evenly distributed in RA and DEC (see figure 4) one would not expect to see much of a difference in comparison with the cluster data. The Lee statistic for group 2 has a slightly higher value of $L_{RAT}$, but the $p$ value still rejects any statistically significant substructure. The Lee statistic result for group 2 is plotted in figure 5b. It does not differs greatly from that of the cluster dataset showing the elongation angle $\phi_{\text{max}}=82.8^\circ$.

Of the three 3D tests only the $\Delta$ test statistic gave a positive rejection of the Gaussian hypothesis. This may be a false positive since no other estimators gave the same result and, as pointed out by Bird 1993, the $\Delta$ test is the more optimistic of the three. This result coupled with a low $L_{RAT}$ for group 2 from the Lee statistic lends support to the 3D tests null result.

5.1.4. Rotation

As pointed out by Malumuth et al. 1992 a smooth gradient in the velocity field may complicate use of the $\Delta$ statistic by giving a false positive substructure result. Even though in Abell 119 the $\Delta$ statistic has a null hypothesis for the cluster data set one is still interested in knowing whether clusters in general show signs of rotation. An estimate of cluster rotation can be made by calculating a binned $C_{BI}$ along the elongation axis (as defined by the Lee statistic). Figure 6a shows $C_{BI}(R)$-$C_{BI}(\text{global})$ versus $R$ with 90% bootstrapped confidence intervals. There is no clear gradient in the data and therefore
implies little in the way of cluster rotation. There is however a strong discontinuity at radii of around $1 \, \text{h}^{-1}\text{Mpc}$. This could just be a sampling effect. If one looks at the original positions as measured from the ESO plates (figure 1a) one cannot help but see two “voids” in the lower left hand corner and upper right hand corner at about $1 \, \text{h}^{-1}\text{Mpc}$ in radius. This also manifests itself in the measured velocities (figure 4).

For group 2 (figure 6b) much the same situation as above is found. No clear gradients seem to exist, although the discontinuous feature at $\sim 1 \, \text{h}^{-1}\text{Mpc}$ persists, as expected. This result would tend to support the $\Delta$ test finding of substructure in group 2 given a lack of evidence for any strong velocity field gradients.

5.1.5. Velocity Dispersion Profile (VDP)

Variations in the velocity dispersion with radius may indicate a condition of non-equilibrium (Kaiser 1987). To test this for “the cluster” figure 7a plots radius versus velocity. The caustics for “the cluster” data are well defined except for three points at the top of figure 7a. Eliminating these three points (which are actually part of the background group picked with KMM) a plot of the cumulative $S_{BI}$ (velocity dispersion) versus radius is shown in figure 8a. As one can see in figure 8a, the velocity dispersion falls with radius as is seen with many well studied rich clusters (e.g. Abell 3266 in Quintana et al. 1996, and others in [Hartog & Katgert 1996]).

For group 2 radius versus velocity is show in figure 7b and cumulative velocity dispersion versus radius in figure 8b. Now the situation has changed dramatically. Both plots show a roughly flat distribution, even out to large radii. Either the fore and background groups have been eliminated incorrectly (which is not supported by the previous work of Fabricant et al. 1993 nor the X-ray data) or one is witnessing the effects of velocity anisotropies
in the central region (Fadda et al. 1996) where the effects of dynamical friction may be slowing down the more luminous central galaxies. One may recall that the frictional force is proportional to the local matter density (Chandrasekhar 1943) which is higher in the central region of a cluster. As well, den Hartog & Katgert 1996 agree that it may be anisotropic projection effects that cause inverted VDPs. Group 2 does not have an inverted VDP, but it may help to explain the flat VDP seen.

5.1.6. Rosat versus AKM

Using the adaptive kernel map (AKM) first applied by Beers et al. 1991 to the 2-D galaxy distribution one can attempt to make a comparison between the contours generated from the number density of galaxies deemed to be in group 2, and that from the X-ray density contours of Rosat.

Figures 9a and 9b show the Rosat and AKM contour optical overlays for a 1.5x1.5 $h^{-1}$Mpc region centered on the central cD. The data is restricted to the inner 1.5 $h^{-1}$Mpc since at this redshift that is the extent to which one can gain meaningful information from the X-ray data.

The Rosat X-ray data in figure 9b has been smoothed with a 2 pixel FWHM Gaussian using the imsmooth task in the PROS\(^1\) X-ray reduction package. The image was obtained from the publically released HEASARC Rosat CD Volume 2 (Corcoran et al. 1994).

Since both the AKM and Rosat data presented in figures 9a and 9b cover the same 1.5x1.5 $h^{-1}$Mpc region a direct, albeit qualitative, comparison of the matter density

\(^1\)PROS is developed, distributed, and maintained by the Smithsonian Astrophysical Observatory, under partial support from NASA contract NAS5-30934
(Rosat/X-ray) to the 2-D galaxy number density can be made. It is obvious that a NNE elongation in the central regions of both plots manifests itself and in fact coincides with the elongation axis objectively obtained using the Lee test statistic. This strong evidence suggests that if one obtains enough galaxy redshifts in a cluster one can accurately begin to estimate the local matter density with confidence.

5.1.7. Radio

The core of Abell 119 has been radio mapped at 20cm with the VLA by Zhao et al. 1989. They claim the elongation of the cD may indicate a Wide Angle Tailed source. The NNW elongation seen in the radio mapped cD does not correspond to the large scale NNE elongation seen in this cluster. If the cluster had formed recently one might expect to find the radio structure mimicking the larger scale structure, but since this is not the case it is presented as evidence that group 2 was not recently formed, and since one would expect more substructure with younger systems it further supports the lack of substructure seen in the velocity field.

5.1.8. Mass

In Table 5 the mass estimates of the three groups are reported. The virial, average, mean and projected mass estimators as described in Heisler et al. 1985 were used. The mass estimate within 0.5 h^{-1}Mpc for group 2 is reported so as to compare with the Rosat X-ray estimate of Jones 1996. Good agreement within the errors is found for the average and median mass estimators. The mass for R<2.3Mpc is also shown (the limit of this survey) as a rough comparison with the X-ray estimate of Abramopoulos & Ku 1983 (Table 5) who reach a radius of 1.93 h^{-1}Mpc and whose value is far above the higher error bar on
all four mass estimators determined from the data in this paper. This is likely due to the fact that Abramopoulos & Ku 1983 used a $\beta$ (the value of the dimensionless temperature) of 1, whereas other studies (Jones & Forman 1984) have since pointed to values between 0.5 and 0.7 for most clusters of galaxies.

In Table 5 calculated masses are also shown for subgroups 1 and 3. As noted in section 5.1.1 these groups are not likely to be virialized. This is because they are being tidally disrupted by the gravitational field of the main cluster group which would distort their distribution and prevent one from obtaining an accurate estimate of the mass using the virial theorem. Nonetheless the numbers are printed here for comparison with any future estimates.

5.2. Abell 133

5.2.1. 1D tests

ROSTAT and $3\sigma$ iterative clipping were employed to keep 120 velocities in the range $15279 < v < 18846$ km sec$^{-1}$. Table 3 shows the 90% confidence intervals about the location ($C_{BI}$) and scale ($S_{BI}$) of the 3 $S_{BI}$ clipped data using 10000 bootstraps.

Table 3 also presents the results of the shape estimators on the velocity distribution (see figure 10a). Of the 4 estimators only the large kurtosis value would lead one to believe the distribution is non-Gaussian. The kurtosis implies the distribution is heavily tailed and that one should run KMM to look for in-falling groups along the line of sight. Attempts to identify two, three, four and five groups all failed with large margins. No multi-group fit came back with a null rejection of the single Gaussian hypothesis.

Given the failure of KMM to discern any multiple Gaussian structure one must look to the $Z_{score}$, 2D and 3D tests for any confirmation of the kurtosis.
5.2.2. cD velocity offset, $Z_{score}$

Table 4 shows the $Z_{score}$ and cD peculiar velocity for Abell 133. There is a case for a “speeding cD” given the fact that the $Z_{score}$ value with error does not bracket zero. Given that no possible host subclumps have been objectively verified one must assume this an indicator of dynamical youth. See the VDP section below for more.

5.2.3. 2D and 3D tests

Table 4 also presents the 2D and 3D results using the 120 galaxies within 3$S_{BI}$. Note that the centroid of the galaxy positions was taken as the center of the cluster. This was justified by the $Z_{score}$ value indicating the cD is not at the center of the cluster, and therefore not a good place to pick the cluster center. It is important to pick a good center as some of the substructure indicators are sensitive to this value.

The Lee statistic has a small p value of 15. This indicates that a two group fit versus one is likely. Recall again that a p value of less than 25 indicates a statistically significant probability. Figure 10b shows a plot of the Lee distribution with a peak at 93.6°.

The lack of multiple peaks and the high value of $L_{RAT}$ (Table 4) continue to insist that no more than two groups are likely in the X-Y plane. The Lee statistic was also run on the inner 1.5 $h^{-1}$Mpc region so as to compare with the AKM and Rosat data below. There were two peaks in the Lee distribution implying more complex structure as mentioned. One peak was at 88° which corresponds to the elongation seen in the AKM and Rosat maps (see section 5.2.6).

The other 3D estimators should verify this 2-D structure if it exists. While these estimators are not proficient at LOS substructure (which, outside the Kurtosis and Lee results, the 1D tests and KMM failure have ruled out) they are sensitive to 2D structure
in the plane of the sky. Table 4 contains the values for the $\Delta$, $\alpha$, and $\epsilon$ tests. Only the $\Delta$ statistic indicates a statistically significant level of substructure, in keeping with the Lee statistic. However, again it should be kept in mind that the $\Delta$ is the most optimistic, or most likely to give a false positive of the three.

5.2.4. Rotation

Figure 11a shows the $C_{BI}$ velocities and their 90% confidence intervals binned along the elongation axis as given by the Lee statistic. There are no clear gradients which would indicate rotation.

This further emphasizes the $\Delta$ statistic result above. If one did see signs of rotation this might show up as a positive substructure result in the $\Delta$ test where small values of $V_{\text{rot}}/\sigma$ may cause detection by the 3-D diagnostics. Since there are no signs of rotation in $C_{BI}$ one can put more confidence in the $\Delta$ statistic result.

However there are discontinuities at -1 and 1.25 $h^{-1}\text{Mpc}$. The discontinuity at -1 may be explained by the low number of galaxies in the last two bins and the lack of sample south of 1.5 $h^{-1}\text{Mpc}$.

5.2.5. Velocity Dispersion Profile (VDP)

As for Abell 119 variations in the velocity dispersion were tested by plotting velocity versus radius (the caustics) in figure 11b and cumulative $S_{BI}$ in figure 11c. Both plots are fairly flat out to 2.5 $h^{-1}\text{Mpc}$ as in group 2 of Abell 119. The flat VDP within 1 $h^{-1}\text{Mpc}$ is again an indicator of galaxy velocity anisotropies and is supported by our $Z_{\text{score}}$ result for Abell 133.
5.2.6. Rosat versus AKM

Figures 12a and 12b show the AKM and Rosat contour optical overlays for a 1.5x1.5 h\(^{-1}\)Mpc region centered on the central cD. These are once again restricted to the inner 1.5 Mpc since that is the extent to which one can gain meaningful information from the X-ray data at this distance.

The Rosat X-ray data has been smoothed with a 2 pixel FWHM Gaussian using the imsmooth task in the PROS X-ray reduction package. As above, the image was obtained from the publically released HEASARC Rosat CD Volume 2 (Corcoran et al. 1994).

If one focuses on the inner regions one can discern a slight NNE SWW elongation of the X-ray gas and galaxy distribution. As one goes farther away from the center the contours push out to the SE in both maps. This is in agreement with the elongation seen in the Lee statistic result for data within 1.5 h\(^{-1}\)Mpc. As well there appears to be small structures, again supported by the flat VDP.

5.2.7. Radio

Abell 133 has been reported as a strong radio source and studied by several groups (Slee et al. 1989, Owen et al. 1993, Gregorini et al. 1994). The radio structure of the cD has been resolved into two sources by Owen et al. 1993 (figure 1), but the orientation of the double structure does not correspond to the elongation axis of the cluster. The wide area radio map by Slee et al. 1989 (figure 9) also resolves the multiple cD components, but otherwise has no correspondence with the elongation angle of the cluster. As for Abell 119 if the cluster had formed recently one might expect to find the radio structure mimicking the larger scale structure, but since this is not the case it is presented as evidence of an older system with little substructure.
5.2.8. Mass

Table 5 compares this paper’s mass estimate for Abell 133 with the X-ray mass estimates of [Jones 1996] for $R < 0.5h^{-1}\text{Mpc}$ and $R < 1.5h^{-1}\text{Mpc}$. For $R < 0.5h^{-1}\text{Mpc}$ all four mass estimates are in agreement with the X-ray data within their respective 90% confidence intervals. For $R < 1.5h^{-1}\text{Mpc}$ of the four estimators only the projected mass estimator (PME) does not overlap with the X-ray value. This is quite a surprising result given the substructure seen in the Rosat image in combination with the Lee, $\Delta$, $Z_{\text{score}}$, and VDP results suggesting a system non-ideal for virial estimates of mass.

6. Discussion

Starting with 174 galaxies in Abell 119, which include this paper’s newly recorded velocities and those obtained from the literature, 3 sigma iterative clipping left 155. From the 1-D velocity distribution the ROSTAT statistical program yielded a high positive kurtosis in the remaining 155 galaxies pointing to tails heavier than expected for a Gaussian distribution. Subsequently the KMM partitioning algorithm was used to search for overlapping Gaussian distributions in the velocity field. Three overlapping distributions were found rejecting the single Gaussian distribution at the 97.9% confidence level. A main group of 125 members and two smaller groups of 11 and 17 were found. Further 1-D analysis with ROSTAT on the main subgroup of 125 members (group 2) lent support to a Gaussian distribution of velocities, while this was not the case for the 2 smaller sub groups. As well, the central galaxy was not significantly offset from the mean velocity of the cluster in group 2 implying the lack of a speeding cD. The 2-D Lee statistic did not detect two groups in group 2, but did lend support to an elongation axis near $82.8^\circ$. Of the 3-D tests used on group 2 only the Delta test was positive, but it should be noted that it is the more likely to detect a false positive of the 3-D estimators. No clear gradients were found in the
velocity field of group 2, further supporting the delta statistic which is susceptible to such gradients. The flat velocity dispersion profile for group 2 points to velocity anisotropies in the central region. Rosat X-ray data was compared with the number density of galaxies in group 2 as plotted using an Adaptive Kernel Map (AKM) within 1.5h$^{-1}$Mpc of the central cD galaxy. The elongation pointed out with the Lee statistic is replicated in both the Rosat and AKM maps implying that if one obtains enough galaxy redshifts in a cluster one can accurately begin to estimate the local matter density with confidence. Virial mass estimates of [Jones 1996] from Rosat data compare nicely with those obtained from the velocity data presented here for those galaxies within 1.5h$^{-1}$Mpc of the central galaxy of group 2.

In Abell 133 a dynamical analysis using newly collected velocity data in combination with that of the literature was done starting with 153 velocities. 3 sigma iterative clipping reduced the 153 to 120. The remaining 1-D velocity data was analyzed with ROSTAT to yield a relatively high positive kurtosis, but when KMM was used to search for multiple Gaussian fits none were found with a significance level higher than that of a single Gaussian. However, the central cD galaxy was significantly offset from the cluster mean velocity which is an indicator of dynamical youth especially since there appears no host subclump for the central cD galaxy. This is further supported by the flat velocity dispersion profile seen in the inner part of the cluster implying velocity anisotropies. The Lee statistic was positive for a 2 group fit, but of the 3-D statistical indicators only the delta statistic supported the finding. However the delta statistic result itself was further supported by the lack of velocity gradients in the C$_{BI}$ velocities along the elongation axis found with the Lee statistic. The Lee statistic run on the inner 1.5h$^{-1}$Mpc gives an elongation axis at 88°, which corresponds to what is seen in the Rosat and AKM images. The Lee statistic run on this portion of the data does show multiple peaks indicating more complex structure, also supported by what is seen in the Rosat image. The complex structure found above is again bolstered by the flat VDP seen, indicating velocity anisotropies in the inner regions of the cluster. All 4
mass estimates agree with the exception of the one for the projected mass estimator within R<1.5h^{-1}Mpc. This is quite a surprising result given the substructure seen in the Rosat image in combination with the Lee, Δ, Z_{score}, and VDP results which suggest a system non-ideal for virial estimates of mass. This can only be disentangled in the future by further velocity measurements in the field of this cluster.

Both of these X-ray clusters seem to demonstrate virialization to large radii given the good correlation between the X-ray and velocity mass estimators. However the Lee statistic for both of these clusters points to an elongation of the cluster. In Abell 133 a hint at two groups in the plane of the sky is also observed. In Abell 119 the elongation is less pronounced than that of Abell 133 where within 1 h^{-1} Mpc the distribution of galaxies gives one the qualitative impression of a small group falling toward the cD galaxy. The X-ray gas in this region of Abell 133 is also elongated in the center as can be seen in figure 12b. The situation for Abell 133 seems much more clear than that of Abell 119. Most of the indicators point to substructure in Abell 133, whereas in Abell 119 the results are more mixed. In either case it is clear that when substructure is taken into account via the statistical methods demonstrated within this paper the velocity+spatial versus X-ray virial estimators can compare nicely.

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Fig. 1.— X-Y positions for galaxies in Abell 119 picked from the ESO Quick Blue survey plates.

Fig. 2.— X-Y positions for galaxies in Abell 133 picked from the ESO Blue plates.

Fig. 3.— Velocity residuals between Abell 133 and 119 in this paper and Melnick & Quintana (1981). A 0th order Polynomial line was fit for those values within 3.0 $\sigma$ of the mean.

Fig. 4.— Velocity between Abell 133 and 119 in this paper and Fabricant et al. 1993. Same line fitting technique as used in Figure 2a.

Fig. 5.— Velocity histogram of Abell 119 for the 153 galaxies within 3$S_{BI}$.

Fig. 6.— Velocity histogram of Abell 119 Group 2.

Fig. 7.— Three groups from the 3$S_{BI}$ clipped Abell 119 data partitioned with KMM. Group 1 is denoted by $\Box$ (11 members), group 2 by $\bullet$ (125 members) and group 3 by $+$ (17 members).

Fig. 8.— Lee statistic for Abell 119, LRAT = 2.231374, N$_{gal}$ = 153.

Fig. 9.— Lee statistic for Abell 119 group 2, LRAT = 1.5829, N$_{gal}$ = 125.

Fig. 10.— Abell 119 C$_{BI}(R)$-C$_{BI}$(global) versus R. There is no clear gradient in the data implying a lack of any clearly definable rotation.

Fig. 11.— Abell 119 Group 2 C$_{BI}(R)$-C$_{BI}$(global) versus R. Once again there is no clear gradient in the data implying a lack of any clearly definable rotation.

Fig. 12.— Caustics for Abell 119 (153 galaxies).

Fig. 13.— Caustics for Abell 119 Group 2 (125 galaxies).
Fig. 14.— Abell 119: Binned cumulative $S_{BI}$ versus R. (153 galaxies).

Fig. 15.— Abell 119 Group 2: Binned cumulative $S_{BI}$ versus R. (125 galaxies).

Fig. 16.— Abell 119 Rosat X-ray - optical map overlay within $R < 1.5h^{-1}$Mpc.

Fig. 17.— Abell 119 Group 2 Adaptive Kernel - optical map overlay within $R < 1.5h^{-1}$Mpc.

Fig. 18.— Abell 133 Velocity Histogram for the 120 galaxies within $3S_{BI}$.

Fig. 19.— Lee statistic for Abell 133. LRAT = 2.415

Fig. 20.— Abell 133 $C_{BI}(R)$-$C_{BI}$(global) versus R. There is no clear gradient in the data implying a lack of any clearly definable rotation.

Fig. 21.— Caustics for Abell 133.

Fig. 22.— Abell 133: Binned cumulative $S_{BI}$ versus R.

Fig. 23.— Abell 133 Rosat X-ray - optical map overlay within $R < 1.5h^{-1}$Mpc.

Fig. 24.— Abell 133 Adaptive Kernel - optical map overlay within $R < 1.5h^{-1}$Mpc.
| Ident. | $\alpha$ (1950) | $\delta$ (1950) | $v_\odot$ | err | R | Ref | Id.Ref | $\overline{v}_\odot$ | err |
|-------|----------------|----------------|------------|-----|---|-----|--------|----------------|-----|
| 25007 | 0 50 25.9      | -02 03 29.6    | 13586      | 66  | 4.5 | fibr |        |                |      |
| 25003 | 0 50 39.1      | -01 04 16.2    | 40924      | 76  | 3.9 | fibr |        |                |      |
| 25005 | 0 50 46.8      | -01 34 08.5    | 13148      | 45  | 6.2 | fibr |        |                |      |
| 25012 | 0 50 55.9      | -00 56 53.8    | 13089      | 70  | 3.5 | fibr |        |                |      |
| 25024 | 0 51 08.1      | -02 12 05.0    | 13782      | 29  | 10.1| fibr |        |                |      |
| 25020 | 0 51 09.2      | -01 21 22.2    | 13027      | 42  | 6.1 | fibr |        |                |      |
| 25015 | 0 51 12.7      | -01 03 04.5    | 41345      | 57  | 4.9 | fibr |        |                |      |
| 25017 | 0 51 13.4      | -01 09 14.7    | 14173      | 38  | 7.9 | fibr |        |                |      |
| 25018 | 0 51 14.4      | -01 11 41.9    | 14082      | 89  | 2.4 | fibr |        |                |      |
| 25027 | 0 51 18.4      | -02 11 16.3    | 20624      | 89  | 3.9 | fibr |        |                |      |
| 25031 | 0 51 25.7      | -01 32 21.7    | 16058      | 50  | 6.1 | fibr |        |                |      |
| 25030 | 0 51 25.7      | -01 43 26.0    | 13083      | 48  | 6.4 | fibr |        |                |      |
| 25040 | 0 51 37.5      | -02 13 25.1    | 13480      | 39  | 8.7 | fibr |        |                |      |
| 25038 | 0 51 38.8      | -01 41 57.8    | 13060      | 32  | 8.8 | fibr |        |                |      |
| 25035 | 0 51 41.3      | -00 55 33.0    | 43573      | 130 | 2.9 | fibr |        |                |      |
| 25045 | 0 51 42.2      | -02 04 04.7    | 13813      | 51  | 4.3 | fibr |        |                |      |
| 25047 | 0 51 42.6      | -01 30 36.9    | 13506      | 31  | 8.7 | fibr |        |                |      |
| 25049 | 0 51 52.7      | -01 11 56.5    | 12742      | 39  | 7.0 | fibr |        |                |      |
| 25057 | 0 52 05.5      | -01 50 42.0    | 12666      | 42  | 6.0 | fibr |        |                |      |
| 25058 | 0 52 07.7      | -01 50 44.3    | 12464      | 37  | 7.5 | fibr |        |                |      |
| 25065 | 0 52 08.6      | -01 23 39.6    | 15944      | 53  | 5.1 | fibr |        |                |      |
| 25062 | 0 52 08.9      | -01 45 35.9    | 11910      | 41  | 6.9 | fibr |        |                |      |
| 25064 | 0 52 16.1      | -01 39 33.8    | 13989      | 31  | 9.5 | fibr |        |                |      |
| 25063 | 0 52 17.4      | -01 45 00.4    | 13889      | 37  | 7.9 | fibr |        |                |      |
| 25061 | 0 52 20.2      | -01 50 50.6    | 13995      | 31  | 8.5 | fibr |        |                |      |
| 25076 | 0 52 22.5      | -01 43 24.6    | 29368      | 50  | 4.9 | fibr |        |                |      |
| 25078 | 0 52 23.5      | -01 57 29.2    | 30284      | 98  | 5.1 | fibr |        |                |      |
| 25077 | 0 52 23.9      | -01 51 19.6    | 32394      | 61  | 4.8 | fibr |        |                |      |
| 25079 | 0 52 25.5      | -02 09 06.3    | 13681      | 45  | 6.8 | fibr |        |                |      |
| 25075 | 0 52 30.2      | -01 35 17.1    | 13883      | 92  |     | fibr |        |                |      |
| 25073 | 0 52 31.7      | -01 31 23.6    | 13011      | 27  | 10.1| fibr |        |                |      |
| 25072 | 0 52 32.2      | -01 30 15.8    | 13351      | 56  |     | fibr |        |                |      |
| 25070 | 0 52 35.5      | -01 19 00.8    | 13777      | 26  | 10.9| fibr |        |                |      |
| 25092 | 0 52 37.8      | -01 04 50.5    | 13663      | 36  | 7.6 | fibr |        |                |      |
| 25088 | 0 52 40.3      | -01 20 46.8    | 14569      | 80  | 6.7 | fibr |        |                |      |
| 25090 | 0 52 43.5      | -01 11 18.5    | 13242      | 32  | 9.1 | fibr |        |                |      |
| 25086 | 0 52 44.6      | -01 33 24.8    | 13546      | 46  | 1   | fibr |        |                |      |
| 25085 | 0 52 45.2      | -01 35 19.3    | 14166      | 84  |     | fibr |        |                |      |
| 25087 | 0 52 45.5      | -01 32 52.1    | 13427      | 30  | 11.7| fibr |        |                |      |
|        |                |                | 13390      | 50  |     | MQ81 |        |                |      |
| Ident. | α (1950) | δ (1950) | $v_\odot$ | err | R | Ref | Id.Ref | $\bar{v}_\odot$ | err |
|-------|----------|----------|----------|-----|---|-----|--------|----------------|-----|
| 25083 | 0 52 48.0 | -01 37 23.3 | 12490 | 42 | 7.0 | fibr | 12594 | 42 |
| 25099 | 0 52 49.6 | -01 28 53.8 | 12577 | 56 | 5.0 | fibr | | |
| 25105 | 0 52 51.9 | -01 34 45.6 | 12472 | 27 | 12.1 | fibr | FAB93 | 69 |
| 25094 | 0 52 52.3 | -01 00 45.5 | 13356 | 42 | 6.7 | fibr | | |
| 25098 | 0 52 56.1 | -01 24 11.4 | 11887 | 26 | 11.6 | fibr | 11887 | 26 |
| 25107 | 0 52 57.2 | -01 41 04.8 | 12873 | 34 | 9.7 | fibr | | |
| 25106 | 0 52 58.2 | -00 48 02.3 | 13963 | 54 | 5.7 | fibr | | |
| 25100 | 0 52 58.3 | -01 17 37.4 | 34667 | 47 | 5.8 | fibr | | |
| 25119 | 0 52 58.9 | -01 28 53.7 | 13810 | 44 | 5.3 | fibr | | |
| 25122 | 0 53 06.6 | -01 45 34.6 | 12845 | 36 | 9.0 | fibr | | |
| 25126 | 0 53 07.3 | -01 34 58.0 | 13017 | 35 | 7.8 | fibr | 13033 | 30 |
| 25137 | 0 53 09.7 | -01 18 15.2 | 12655 | 32 | 7.7 | fibr | 12658 | 30 |
| 25129 | 0 53 11.5 | -01 29 11.1 | 12529 | 51 | 4.4 | fibr | | |
| 25125 | 0 53 11.9 | -01 35 42.0 | 13770 | 31 | 9.5 | fibr | 13746 | 41 |
| 25111 | 0 53 13.2 | -02 07 21.3 | 13190 | 58 | 4.8 | fibr | | |
| 25116 | 0 53 14.5 | -01 58 24.0 | 12857 | 45 | 5.7 | fibr | 12906 | 47 |
| 25148 | 0 53 17.7 | -01 26 06.0 | 14385 | 47 | 6.2 | fibr | 14330 | 48 |
| 25159 | 0 53 18.9 | -01 46 20.1 | 13104 | 33 | 9.3 | fibr | 13118 | 30 |
| 25144 | 0 53 20.1 | -01 10 16.6 | 13247 | 31 | 9.6 | fibr | 13282 | 90 |
| 25146 | 0 53 20.8 | -01 11 35.0 | 13294 | 39 | 7.6 | fibr | MQ81 | 17 |
| 25145 | 0 53 21.1 | -01 11 25.7 | 13633 | 43 | 7.8 | fibr | MQ81 | 9 |
| 25151 | 0 53 22.3 | -01 31 03.0 | 12179 | 40 | 8.5 | fibr | 12189 | 30 |
| 25144 | 0 53 25.7 | -01 34 14.6 | 14697 | 39 | 9.1 | fibr | 14692 | 30 |
| 25163 | 0 53 28.6 | -01 49 12.7 | 12705 | 40 | 7.1 | fibr | 12717 | 37 |
| 25157 | 0 53 29.3 | -01 36 16.9 | 12795 | 30 | 11.2 | fibr | | |
| 99999 | 0 53 30.0 | -01 35 00.0 | 12851 | 73 | | ZAB93 | | |
| 25143 | 0 53 29.8 | -01 05 53.8 | 13408 | 29 | 10.3 | fibr | | |
| 25165 | 0 53 30.0 | -02 12 06.3 | 4048 | 25 | 5.0 | fibr | | |
| 25201 | 0 53 31.8 | -00 43 30.8 | 12895 | 53 | 5.0 | fibr | | |
| Ident. | $\alpha$ (1950) | $\delta$ (1950) | $v_\odot$ | err | R    | Ref | Id. Ref | $v_\odot$ | err |
|--------|----------------|----------------|---------|-----|------|-----|---------|---------|-----|
| 25191  | 0 53 32.5      | -01 19 38.9    | 12949  | 41  | 6.5  | fibr | 12935  | 35   |
|        |                |                | 12928  | 64  |      |      |         |        |     |
| 25170  | 0 53 33.7      | -01 36 49.2    | 13844  | 29  | 10.3 | fibr | 13836  | 30   |
|        |                |                | 13836  | 54  |      |      |         |        |     |
| 25175  | 0 53 36.9      | -01 32 16.6    | 13690  | 56  |      |      |         |        |     |
| 25187  | 0 53 37.0      | -01 24 37.7    | 14517  | 29  | 9.4  | fibr | 14516  | 30   |
|        |                |                | 14540  | 50  |      |      |         |        |     |
| 25190  | 0 53 37.3      | -01 23 13.7    | 12497  | 36  | 8.7  | fibr | 12501  | 33   |
|        |                |                | 12565  | 80  |      |      |         |        |     |
| 25166  | 0 53 38.0      | -01 48 06.0    | 14741  | 37  | 8.1  | fibr | 14736  | 30   |
|        |                |                | 14758  | 42  |      |      |         |        |     |
| 25199  | 0 53 38.9      | -00 50 44.5    | 13230  | 70  | 3.5  | fibr |         |      |
| 25186  | 0 53 40.9      | -01 24 52.2    | 13491  | 30  | 9.0  | fibr | 13476  | 30   |
|        |                |                | 13452  | 56  |      |      |         |        |     |
| 25180  | 0 53 42.7      | -01 31 32.3    | 13326  | 35  | 10.1 | fibr | 13282  | 38   |
|        |                |                | 13320  | 100 |      |      |         |        |     |
|        |                |                | 13246  | 45  |      |      |         |        |     |
| 25220  | 0 53 42.9      | -01 35 01.9    | 12693  | 47  | 5  e | fibr | 12711  | 30   |
| 25229  | 0 53 43.1      | -01 48 48.6    | 13109  | 46  | 7.6  | fibr | 13125  | 31   |
|        |                |                | 13166  | 41  |      |      |         |        |     |
| 25207  | 0 53 43.6      | -01 13 24.6    | 42012  | 48  | 7.0  | fibr |         |      |
| 25179  | 0 53 44.4      | -01 31 50.1    | 11712  | 41  |      |      |         |      |
| 25178  | 0 53 44.5      | -01 31 56.5    | 11554  | 86  |      |      |         |      |
| 25181  | 0 53 44.8      | -01 30 43.3    | 13131  | 36  | 9.4  | fibr | 13129  | 30   |
|        |                |                | 13170  | 50  |      |      |         |        |     |
| 25188  | 0 53 45.0      | -01 24 17.2    | 11061  | 48  |      |      |         |      |
| 25213  | 0 53 47.6      | -01 26 48.1    | 11730  | 34  | 8.8  | fibr | 11717  | 60   |
|        |                |                | 11480  | 160 |      |      |         |        |     |
| 25227  | 0 53 48.5      | -01 43 11.0    | 13933  | 44  | 5.6  | fibr |         |      |
| 25214  | 0 53 49.5      | -01 28 47.8    | 14945  | 29  | 11.3 | fibr | 14873  | 175  |
|        |                |                | 14705  | 50  |      |      |         |        |     |
| 25208  | 0 53 50.1      | -01 15 25.4    | 13179  | 43  | 11.4 | fibr | 13185  | 39   |
|        |                |                | 13255  | 90  |      |      |         |        |     |
| 25212  | 0 53 51.2      | -01 24 47.5    | 12886  | 31  | 9.8  | fibr | 12839  | 77   |
|        |                |                | 12760  | 50  |      |      |         |        |     |
| 25217  | 0 53 52.2      | -01 31 57.1    | 11434  | 31  | 10.4 | fibr | 11456  | 30   |
|        |                |                | 11575  | 250 |      |      |         |        |     |
|        |                |                | 11541  | 48  |      |      |         |        |     |
| 25233  | 0 53 52.2      | -02 05 02.7    | 13866  | 43  | 6.0  | fibr | 12995  | 80   |
| 25218  | 0 53 52.5      | -01 32 42.6    | 13041  | 44  | 7.7  | fibr | 12765  | 80   |
|        |                |                | 13069  | 49  |      |      |         |        |     |
| 25230  | 0 53 53.2      | -01 53 46.5    | 13706  | 37  | 8.4  | fibr | 13731  | 41   |
|        |                |                | 13826  | 61  |      |      |         |        |     |
| 25206  | 0 53 53.9      | -01 03 45.0    | 12948  | 46  | 4.9  | fibr | 13467  | 32   |
| 25225  | 0 53 54.6      | -01 42 19.9    | 13458  | 32  | 9.3  | fibr |         |      |
|        |                |                | 13607  | 111 |      |      |         |      |
| Ident. | α (1950) | δ (1950) | v⊙ | err | R | Ref | Id.Ref | v⊙ | err |
|--------|----------|----------|-----|-----|---|-----|--------|-----|-----|
| 25216  | 0 53 55.8| -01 29 49.1| 11404| 100 | FAB93 | 59 |
| 25241  | 0 53 57.1| -01 48 15.1| 14461| 29  | 9.8 | fibr | 12655| 30 |
| 25251  | 0 53 57.3| -01 26 35.2| 12657| 29  | 10.0| fibr | 12678| 41 |
| 25239  | 0 53 58.1| -01 53 12.0| 13586| 71  | FAB93 | 74 |
| 25245  | 0 53 58.2| -01 37 54.9| 12766| 35  | 7.4 | fibr | 12758| 32 |
| 25237  | 0 53 59.3| -02 2 32.5| 3970 | 100 | MQ81 | 21 | 4006 | 30 |
| 25250  | 0 54 02.3| -01 32 08.7| 13248| 57  | 5.5 | fibr | 13247| 88 |
| 25257  | 0 54 02.4| -00 48 04.2| 13258| 61  | 4.1 | fibr | 13383| 36 |
| 25240  | 0 54 03.9| -01 48 36.8| 13127| 39  | 6.7 | fibr | 13142| 36 |
| 25253  | 0 54 05.0| -01 23 46.3| 13535| 33  | 7.9 | fibr | 13198| 42 |
| 25244  | 0 54 05.2| -01 39 38.2| 13187| 30  | 10.1| fibr | 13380| 30 |
| 25246  | 0 54 05.3| -01 37 19.1| 13383| 36  | 8.8 | fibr | 13380| 30 |
| 25248  | 0 54 05.7| -01 33 55.4| 15211| 56  | 4.6 | fibr | 15079| 150|
| 25242  | 0 54 06.4| -01 44 42.3| 12908| 28  | 10.0| fibr | 13270| 38 |
| 25254  | 0 54 07.5| -01 18 16.5| 13313| 49  | 6.6 | fibr | 14057| 30 |
| 25263  | 0 54 11.1| -01 08 41.5| 14064| 34  | 8.8 | fibr | 13270| 38 |
| 25281  | 0 54 12.8| -01 48 51.5| 12034| 35  | 9.0 | fibr | 13504| 71 |
| 25275  | 0 54 13.0| -01 33 03.5| 12610| 30  | 4.1 | fibr | 13504| 71 |
| 25282  | 0 54 13.3| -01 52 00.7| 13456| 41  | 6.2 | fibr | 15079| 150|
| 25262  | 0 54 13.6| -01 08 53.1| 13059| 40  | 8.0 | fibr | 15079| 150|
| 25285  | 0 54 13.9| -02 03 22.2| 12391| 65  | 3.8 | fibr | 12256| 30 |
| 25258  | 0 54 15.9| -00 53 44.3| 13772| 35  | 6.9 | fibr | 12256| 30 |
| 25274  | 0 54 18.1| -01 32 33.0| 12245| 30  | 11.1| fibr | 12256| 30 |
| 25271  | 0 54 19.3| -01 25 44.8| 13748| 28  | 9.3 | fibr | 13724| 30 |
| 25266  | 0 54 23.0| -01 12 48.6| 12791| 42  | 7.1 | fibr | 13724| 30 |
| 25280  | 0 54 23.4| -01 43 23.1| 13848| 57  | 4.9 | fibr | 15048| 41 |
| 25273  | 0 54 23.5| -01 28 54.0| 14964| 76  | 2.9 | fibr | 15048| 41 |
| 25289  | 0 54 23.7| -01 39 31.9| 13091| 33  | 8.3 | fibr | 15048| 41 |
| 25290  | 0 54 24.9| -01 38 58.1| 14806| 42  | 6.4 | fibr | 15048| 41 |
| 25294  | 0 54 25.2| -01 31 37.1| 13523| 80  | FAB93 | 57 |
| 25301  | 0 54 26.8| -01 05 42.8| 14589| 70  | 4.1 | fibr | 13911| 30 |
| 25303  | 0 54 27.9| -01 01 33.1| 12984| 50  | 5.8 | fibr | 13911| 30 |
| 25298  | 0 54 28.5| -01 08 59.4| 13913| 27  | 10.5| fibr | 13911| 30 |
|        |          |           | 13935| 39  | FAB93 | 106 |
Table 1. (continued)

| Ident. | \( \alpha \) (1950) | \( \delta \) (1950) | \( v_\odot \) | err | R | Ref | Id.Ref | \( \odot v \) | err |
|--------|-----------------|-----------------|-----------|-----|---|-----|--------|-----------|-----|
| 99999  | 0 54 28.7       | -01 08 45.0     | 13535     |     |   | RC3 | 3405   |           |     |
| 25299  | 0 54 29.0       | -01 08 42.4     | 13060     | 91  | 3.2| fibr |         |           |     |
| 25296  | 0 54 31.5       | -01 11 20.5     | 13451     | 53  | 5.5| fibr | 13377   | 52   |
|        |                 |                 | 13369     | 37  |    |     |         |       |     |
| 25288  | 0 54 33.6       | -01 40 03.0     | 14565     | 37  | 8.2| fibr |         |       |     |
| 25291  | 0 54 36.3       | -01 39 09.9     | 12010     | 31  | 10.7| fibr |         |       |     |
| 25319  | 0 54 37.2       | -01 17 19.2     | 12330     | 52  | 4.7| fibr | 12393   | 108  |
|        |                 |                 | 12625     | 90  |    |     |         |       |     |
| 25292  | 0 54 37.8       | -01 39 00.1     | 14656     | 37  | 7.3| fibr | 14651   | 32   |
|        |                 |                 | 14685     | 62  |    |     |         |       |     |
| 25324  | 0 54 38.7       | -02 01 42.5     | 23761     | 68  | 3.3| fibr |         |       |     |
| 25313  | 0 54 40.3       | -00 55 01.9     | 12654     | 31  | 9.9| fibr | 12666   | 76   |
|        |                 |                 | 13200     | 200 |    |     |         |       |     |
| 25391  | 0 54 40.4       | -01 16 54.7     | 11752     | 36  | 9.0| fibr | 11752   | 36   |
|        |                 |                 | 14765     | 230 |    |     |         |       |     |
| 25392  | 0 54 41.2       | -01 33 20.5     | 12965     | 33  | 8.6| fibr | 12963   | 30   |
|        |                 |                 | 12988     | 41  |    |     |         |       |     |
| 25314  | 0 54 43.4       | -00 56 21.8     | 13518     | 56  | 6.1| fibr | 13636   | 105  |
|        |                 |                 | 13775     | 50  |    |     |         |       |     |
| 25312  | 0 54 47.6       | -00 54 08.7     | 22821     | 89  | 2.8| fibr |         |       |     |
| 25315  | 0 54 51.3       | -01 00 36.0     | 18828     | 55  | 6.4| fibr | 18793   | 38   |
|        |                 |                 | 18788     | 53  |    |     |         |       |     |
| 25310  | 0 54 52.2       | -00 47 22.8     | 12669     | 47  | 6.8| fibr |         |       |     |
| 25329  | 0 54 52.9       | -01 36 48.3     | 13063     | 24  | 11.7| fibr | 13076   | 63   |
|        |                 |                 | 13411     | 117 |    |     |         |       |     |
| 25335  | 0 54 54.0       | -00 44 28.7     | 13156     | 53  | 7.2| fibr |         |       |     |
| 25331  | 0 54 58.4       | -01 11 51.6     | 13434     | 51  |    |     |         |       |     |
| 25328  | 0 55 01.5       | -01 39 39.6     | 13533     | 42  | 7.8| fibr | 13491   | 34   |
|        |                 |                 | 13467     | 71  |    |     |         |       |     |
| 25350  | 0 55 03.0       | -02 08 02.1     | 23799     | 84  | 3.1| fibr |         |       |     |
| 99999  | 0 55 06.0       | -01 38 00.0     | 13427     |     |    | RC3 | 3444   |       |
| 25344  | 0 55 06.4       | -01 09 44.2     | 13761     | 32  | 8.8| fibr | 13745   | 39   |
|        |                 |                 | 13678     | 77  |    |     |         |       |     |
| 25341  | 0 55 06.6       | -00 51 39.6     | 13680     | 66  | 3.7| fibr |         |       |     |
| 25347  | 0 55 08.3       | -01 34 55.2     | 14219     | 67  | 2.8| fibr |         |       |     |
| 25340  | 0 55 12.9       | -00 51 07.0     | 13893     | 68  | 5.2| fibr |         |       |     |
| 25345  | 0 55 15.3       | -01 16 25.3     | 12882     | 36  | 9.7| fibr |         |       |     |
| 25360  | 0 55 18.3       | -01 24 20.5     | 13091     | 53  | 5.2| fibr |         |       |     |
| 25361  | 0 55 20.2       | -01 05 03.7     | 12651     | 47  | 5.4| fibr | 12620   | 40   |
|        |                 |                 | 12598     | 59  |    |     |         |       |     |
| 25352  | 0 55 29.4       | -02 18 29.2     | 12814     | 41  | 6.8| fibr |         |       |     |
| 25362  | 0 55 31.6       | -00 57 32.3     | 12694     | 64  | 3.8| fibr |         |       |     |
| 25374  | 0 55 44.6       | -01 25 06.2     | 15647     | 38  | 10.2| fibr | 15609   | 43   |
|        |                 |                 | 15562     | 42  | 7.5| fibr |         |       |     |
| 25368  | 0 55 47.4       | -02 12 23.7     | 13018     | 37  | 8.0| fibr |         |       |     |
| 25372  | 0 55 51.3       | -01 39 51.0     | 15468     | 75  | 3.8| fibr | 15473   | 70   |
|        |                 |                 | 15510     | 200 |    |     |         |       |     |
Table 1. (continued)

| Ident. | α (1950) | δ (1950) | \(v_\odot\) | err | \(R\) | Ref | Id.Ref | \(v_\odot\) | err |
|--------|----------|----------|-------------|-----|------|-----|--------|-------------|-----|
| 25370  | 0 55 51.5 | -02 05 49.9 | 12661 | 42  | 7.8  | fibr | 12613 | 58 |
| 25381  | 0 55 58.7 | -01 50 20.3 | 12801 | 74  | 3.4  | fibr |        |    |
| 25380  | 0 56 03.6 | -01 05 28.0 | 22697 | 131 | 3.0  | fibr |        |    |
| 25386  | 0 56 13.3 | -01 01 16.5 | 13333 | 66  | 5.1  | fibr |        |    |
| 25385  | 0 56 14.1 | -01 21 59.5 | 13935 | 56  | 4.5  | fibr | 13939 | 40 |
| 25389  | 0 56 24.9 | -01 06 18.0 | 13631 | 34  | 7.8  | fibr |        |    |
| 25392  | 0 56 34.1 | -02 08 26.0 | 24554 | 47  | 5.9  | fibr |        |    |
| 25393  | 0 56 37.4 | -02 10 07.5 | 15582 | 77  | 3.6  | fibr |        |    |
| 25400  | 0 56 42.2 | -00 47 51.8 | 52499 | 95  | 3.3  | fibr |        |    |
| 25398  | 0 56 45.2 | -01 15 25.8 | 13690 | 36  | 7.9  | fibr |        |    |

References for Table 1.
This paper: fibr = LCO fiber spectra; FAB93 = Fabricant et al. (1993); HDTL = Huchra et al. (1983); MQ81 = Melnick & Quintana (1981); KH=Kinman & Hintzen (1981); RC3 = de Vaucouleurs et al. (1991); S78 = Sandage (1978); ZAB93 = Zabludoff et al. (1993)
| Ident. | α (1950) | δ (1950) | $v_\odot$ | err | R | Ref | Id.Ref | $\overline{v}_\odot$ | err |
|-------|-----------|-----------|----------|-----|---|-----|--------|----------------|-----|
| 25022 | 0 57 10.1 | -21 39 48.7 | 16587 | 52 | 4.8 | e | fibr | 16805 | 3582 |
| 25025 | 0 57 29.8 | -21 49 12.6 | 15952 | 49 | 5.7 | fibr | |
| 25026 | 0 57 31.5 | -21 47 54.6 | 17433 | 46 | 6.4 | fibr | |
| 25024 | 0 57 34.9 | -22 02 21.7 | 16400 | 50 | 5.7 | fibr | |
| 25027 | 0 57 35.0 | -21 45 27.5 | 16734 | 40 | 9.5 | fibr | 16753 | 30 |
| 25023 | 0 57 42.8 | -21 30 01.9 | 5635 | 46 | 7 | e | fibr | 5630 | 30 |
| 25035 | 0 57 39.3 | -21 49 00.0 | 16459 | 51 | 3.9 | fibr | |
| 25033 | 0 57 48.2 | -21 32 11.3 | 18297 | 78 | 3.1 | fibr | 5629 | 3 |
| 25039 | 0 58 00.9 | -22 18 27.3 | 16136 | 37 | 7.8 | fibr | |
| 25040 | 0 58 01.1 | -22 28 59.2 | 17249 | 48 | 4.9 | fibr | |
| 25044 | 0 58 55.8 | -21 59 06.1 | 16170 | 151 | 3 | fibr | |
| 25042 | 0 58 05.8 | -22 01 03.0 | 25300 | 40 | 3 | fibr | |
| 25047 | 0 58 12.1 | -21 48 40.7 | 34366 | 36 | 7.7 | fibr | |
| 25048 | 0 58 13.0 | -21 52 04.0 | 17298 | 29 | 9.9 | fibr | 17307 | 30 |
| 25045 | 0 58 18.4 | -21 42 10.0 | 16505 | 38 | 7.0 | fibr | |
| 25050 | 0 58 20.5 | -21 59 35.0 | 12536 | 32 | 10.4 | fibr | |
| 25054 | 0 58 23.4 | -22 03 50.2 | 40375 | 92 | 2.9 | fibr | |
| 25056 | 0 58 27.9 | -21 54 36.4 | 34675 | 54 | 5.2 | fibr | |
| 25057 | 0 58 30.1 | -21 40 29.4 | 17245 | 39 | 7.2 | fibr | |
| 25053 | 0 58 34.0 | -22 05 54.9 | 17680 | 40 | 6.7 | fibr | |
| 25055 | 0 58 35.6 | -21 56 41.0 | 16926 | 44 | 6.6 | fibr | |
| 25058 | 0 58 41.3 | -21 38 13.8 | 16692 | 36 | 7.8 | fibr | |
| 25059 | 0 58 48.9 | -22 24 47.3 | 16593 | 37 | 7.5 | fibr | |
| 25062 | 0 58 50.9 | -22 28 33.7 | 17632 | 84 | 3.0 | fibr | |
| 25061 | 0 58 51.1 | -22 31 23.1 | 16942 | 29 | 10.0 | fibr | |
| 25068 | 0 58 53.3 | -22 11 56.6 | 17005 | 37 | 6.8 | fibr | |
| 25065 | 0 58 54.3 | -22 24 37.4 | 24804 | 29 | 4 | fibr | |
| 25069 | 0 58 56.2 | -21 44 20.0 | 16853 | 29 | 9.2 | fibr | |
| 25070 | 0 58 57.9 | -21 28 38.0 | 16472 | 38 | 7.8 | fibr | |
| 25064 | 0 58 58.1 | -22 26 30.4 | 17475 | 32 | 8.7 | fibr | |
| 25065 | 0 58 58.2 | -22 19 42.0 | 17435 | 41 | 6.6 | fibr | |
| 25067 | 0 58 58.3 | -22 14 33.8 | 15776 | 64 | 5 | fibr | |
| 25071 | 0 59 00.1 | -21 28 38.9 | 5500 | 97 | 3 | fibr | |
| 25084 | 0 59 07.2 | -22 35 06.0 | 17120 | 51 | 4.6 | fibr | |
| 25081 | 0 59 09.3 | -22 19 56.7 | 16020 | 36 | 11.2 | fibr | |
| 25082 | 0 59 11.6 | -22 22 49.5 | 16770 | 38 | 7.6 | fibr | |
| 25077 | 0 59 15.0 | -22 06 40.8 | 16322 | 27 | 9.5 | fibr | |
| 25083 | 0 59 15.2 | -22 28 31.8 | 17407 | 49 | 4.8 | fibr | |
| 25078 | 0 59 15.7 | -22 13 11.1 | 16327 | 113 | 3.0 | fibr | |
| 25074 | 0 59 17.6 | -21 22 50.3 | 16652 | 50 | 6.6 | fibr | |
| 25075 | 0 59 17.6 | -21 23 07.2 | 16625 | 42 | 7.0 | fibr | |
| 25079 | 0 59 20.6 | -22 16 29.6 | 16093 | 32 | 7.5 | fibr | |
| 25085 | 0 59 20.3 | -22 35 09.8 | 15603 | 31 | 5 | fibr | 15585 | 33 |
| Ident.   | α (1950)  | δ (1950)   | $v_\odot$ | err | R   | Ref | Id.Ref | $v_\odot$ | err |
|----------|------------|------------|-----------|-----|-----|-----|--------|----------|-----|
| 15528    |            |            |           | 55  | 5   | e   | fibr   |          |     |
| 25090    | 0 59 23.4  | -22 25 40.7| 15299     | 36  | 6.8 | fibr |         |          |     |
| 25086    | 0 59 28.6  | -22 32 13.2| 15630     | 31  | 3   | e   | fibr   |          |     |
| 25093    | 0 59 31.4  | -21 39 26.1| 16313     | 60  | 5.0 | fibr |         |          |     |
| 25095    | 0 59 31.9  | -21 21 53.2| 30779     | 52  | 5.8 | fibr |         |          |     |
| 25091    | 0 59 32.2  | -22 24 27.4| 16675     | 39  | 7.7 | fibr |         |          |     |
| 25088    | 0 59 34.3  | -22 30 58.6| 17912     | 50  | 4.7 | e   | fibr   |          |     |
| 99999    | 0 59 36.0  | -19 43 06.0| 16891     | 33  |     | RC3 | 3695   |          |     |
| 25112    | 0 59 39.2  | -22 22 25.8| 16403     | 58  | 4.7 | e   | fibr   |          |     |
| 25115    | 0 59 40.4  | -22 27 52.5| 17492     | 27  | 11.3| fibr |         |          |     |
| 25111    | 0 59 40.6  | -22 20 49.1| 15619     | 104 | 3.4 | e   | fibr   |          |     |
| 25100    | 0 59 43.2  | -21 56 58.7| 12479     | 43  | 6   | e   | fibr   |          |     |
| 25113    | 0 59 44.2  | -22 26 16.6| 16839     | 41  | 7.8 | fibr |         |          |     |
| 25097    | 0 59 44.4  | -21 30 36.5| 16797     | 52  | 6.3 | fibr |         |          |     |
| 25098    | 0 59 44.4  | -21 31 16.4| 16482     | 77  | 5.0 | fibr |         |          |     |
| 25101    | 0 59 45.5  | -22 07 19.8| 16719     | 84  | 2.4 | fibr |         |          |     |
| 25102    | 0 59 45.5  | -22 08 16.7| 16315     | 39  | 7.2 | e   | fibr   |          |     |
| 25105    | 0 59 47.8  | -22 12 27.4| 18132     | 34  | 8.9 | fibr |         |          |     |
| 25107    | 0 59 47.2  | -22 13 31.8| 17216     | 149 | 2.7 | fibr |         |          |     |
| 25108    | 0 59 48.2  | -22 15 12.3| 15837     | 36  | 8.4 | fibr |         |          |     |
| 25103    | 0 59 48.3  | -22 08 56.2| 17216     | 44  | 7.4 | fibr |         |          |     |
| 25110    | 0 59 48.4  | -22 16 47.6| 15555     | 64  | 3.5 | e   | fibr   |          |     |
| 99999    | 0 59 50.0  | -19 56 18.0| 17927     | 30  |     | RC3 | 3705   |          |     |
| 25116    | 0 59 50.1  | -22 12 07.8| 16999     | 39  | 7.2 | fibr |         |          |     |
| 25119    | 0 59 50.8  | -22 22 45.5| 17056     | 47  | 7.1 | fibr |         |          |     |
| 25124    | 0 59 51.3  | -22 06 09.4| 17552     | 29  | 10.5| fibr |         |          |     |
| 25122    | 0 59 52.3  | -22 09 07.3| 17373     | 46  | 6.9 | fibr |         |          |     |
| 25118    | 0 59 53.7  | -22 30 36.0| 16249     | 37  | 8.9 | fibr |         |          |     |
| 25123    | 1 00 00.7  | -22 07 18.2| 16263     | 27  | 11.3| fibr |         |          |     |
| 25120    | 1 00 01.7  | -22 15 04.8| 16985     | 37  | 9.0 | fibr |         |          |     |
| 25130    | 1 00 03.6  | -21 47 16.9| 17125     | 33  | 10.0| fibr |         |          |     |
| 25133    | 1 00 03.6  | -22 05 15.0| 16371     | 38  | 8.0 | fibr |         |          |     |
| 25140    | 1 00 04.9  | -22 06 27.8| 16390     | 56  | 6.0 | fibr |         |          |     |
| 25142    | 1 00 05.4  | -22 07 33.1| 12024     | 72  | 4.8 | fibr |         |          |     |
| 25132    | 1 00 07.0  | -21 53 26.1| 28154     | 36  | 7.8 | e   | fibr   |          |     |
| 25144    | 1 00 08.4  | -22 08 44.7| 16846     | 31  | 10.4| fibr |         |          |     |
| 25148    | 1 00 10.7  | -22 10 42.0| 15521     | 80  |     | MK  |         |          |     |
| 25147    | 1 00 11.0  | -22 09 11.0| 16885     | 80  |     | MK  |         |          |     |
| 25143    | 1 00 11.1  | -22 08 22.8| 15415     | 30  | 10.6| fibr |         |          |     |
| 25151    | 1 00 11.9  | -22 14 58.7| 16896     | 46  | 7.3 | fibr |         |          |     |
| 25136    | 1 00 12.4  | -22 06 30.7| 16409     | 40  | 8.8 | fibr |         |          |     |
| 25146    | 1 00 12.9  | -22 09 04.7| 17635     | 31  | 7.7 | fibr |         |          |     |
| 25128    | 1 00 13.3  | -21 36 17.3| 16907     | 47  | 7.6 | fibr |         |          |     |
| 25149    | 1 00 13.7  | -22 13 35.2| 17481     | 36  | 9.3 | fibr |         |          |     |
| 25134    | 1 00 14.7  | -22 05 44.9| 16462     | 33  | 8.3 | fibr |         |          |     |
| Ident. | α (1950) | δ (1950) | \(v_\odot\) | err | R | Ref | Id.Ref | \(\overline{v}_\odot\) | err |
|-------|----------|----------|-----------|-----|---|-----|--------|-----------------|-----|
| 99999 | 1 00 15.7 | -22 08 09.0 | 17551 | 80 | MK |
| 25145 | 1 00 15.2 | -22 09 01.2 | 17052 | 47 | 10.2 | fibr | 17051 | 30 |
|       |           |          | 17089 |    |     | RC3 | 3727   |     |
|       |           |          | 17160 | 100| MK | RC3 | 3730   |     |
| 25150 | 1 00 18.8 | -22 13 36.1 | 16953 | 25 | 12.0 | fibr |
| 25171 | 1 00 21.9 | -21 52 09.7 | 16566 | 33 | 9.2 | fibr |
| 25167 | 1 00 26.8 | -22 00 49.9 | 18326 | 39 | 7.4 | fibr |
| 25153 | 1 00 28.4 | -22 35 31.9 | 16488 | 38 | 7.8 | fibr |
| 25170 | 1 00 28.9 | -21 55 29.3 | 16206 | 42 | 6.3 | fibr |
| 25155 | 1 00 29.9 | -22 16 49.0 | 16746 | 24 | 11.1 | fibr |
| 25158 | 1 00 31.3 | -22 10 12.1 | 17224 | 46 | 7.4 | fibr |
| 25190 | 1 00 33.1 | -22 27 02.7 | 15555 | 39 | 8.4 | fibr |
| 25182 | 1 00 33.4 | -21 58 53.0 | 17195 | 43 | 6.6 | fibr |
| 25168 | 1 00 34.3 | -21 56 48.2 | 17474 | 42 | 7.9 | fibr |
| 25179 | 1 00 36.0 | -21 30 25.0 | 17860 | 99 | 3.2 | e fibr |
| 25169 | 1 00 36.2 | -21 55 48.1 | 16649 | 28 | 9.0 | fibr |
| 25180 | 1 00 36.7 | -21 39 42.9 | 15813 | 54 | 3.2 | e fibr |
| 25181 | 1 00 37.1 | -21 46 47.4 | 17500 | 37 | 8.4 | fibr |
| 25178 | 1 00 38.5 | -21 24 29.2 | 16022 | 58 | 4 | e fibr |
| 25184 | 1 00 45.1 | -22 13 30.7 | 15995 | 29 | 10.8 | fibr | 15985 | 30 |
|       |           |          | 15961 | 45 | 5.6 | fibr |
| 25189 | 1 00 45.9 | -22 21 13.1 | 18307 | 30 | 10.1 | fibr |
| 25187 | 1 00 46.3 | -22 19 09.9 | 18062 | 31 | 8.8 | fibr |
| 25188 | 1 00 46.5 | -22 19 59.2 | 18405 | 42 | 8.8 | fibr |
| 25198 | 1 00 49.7 | -21 24 38.4 | 17716 | 62 | 5.1 | fibr |
| 25196 | 1 00 50.7 | -22 0 51.7 | 15961 | 69 | 4.1 | fibr |
| 25201 | 1 01 05.8 | -21 42 28.7 | 16172 | 45 | 5.3 | fibr |
| 25200 | 1 01 06.9 | -21 26 59.4 | 25883 | 50 | 5.4 | fibr |
| 25199 | 1 01 07.7 | -21 26 25.8 | 25970 | 65 | 5.3 | fibr |
| 25203 | 1 01 09.7 | -22 24 19.2 | 17420 | 45 | 6.8 | fibr |
| 25204 | 1 01 14.5 | -22 30 31.1 | 42414 | 63 | 4.2 | fibr |
| 25210 | 1 01 18.4 | -21 32 16.9 | 17500 | 30 | 9.5 | fibr |
| 25206 | 1 01 20.3 | -22 18 47.0 | 35765 | 45 | 7.7 | fibr |
| 25208 | 1 01 28.1 | -22 10 58.8 | 36588 | 36 | 8.3 | fibr |
| 25209 | 1 01 32.4 | -22 11 27.8 | 36907 | 49 | 5.6 | fibr |
| 25212 | 1 01 33.3 | -21 38 27.1 | 17594 | 57 | 5.0 | fibr |
| 25214 | 1 01 39.5 | -21 53 03.9 | 16228 | 82 | 3.5 | e fibr |
| 25217 | 1 01 53.3 | -22 20 51.3 | 18846 | 39 | 7.8 | fibr |
| 25219 | 1 01 53.9 | -22 02 28.8 | 16865 | 32 | 8.5 | fibr |
| 25215 | 1 01 54.1 | -22 30 08.4 | 18434 | 38 | 8.0 | fibr |
| 25220 | 1 01 54.2 | -21 40 15.5 | 17241 | 55 | 6.1 | fibr |
| 25216 | 1 01 54.8 | -22 29 20.9 | 18494 | 21 | 4 | e fibr |
| 25221 | 1 01 57.4 | -21 33 52.0 | 12394 | 81 | 4 | e fibr |
| 25224 | 1 01 60.0 | -21 48 30.3 | 16715 | 43 | 6.6 | fibr |
| 25225 | 1 02 00.8 | -21 48 33.0 | 17518 | 118 | 3 | e fibr |
| 25227 | 1 02 02.9 | -22 13 39.9 | 37480 | 57 | 4.7 | e fibr |
Table 2. (continued)

| Ident. | $\alpha$ (1950) | $\delta$ (1950) | $v_\odot$ | err | R | Ref | Id.Ref | $\nu_\odot$ | err |
|--------|-----------------|-----------------|-----------|-----|---|-----|--------|-------------|-----|
| 25228  | 1 02 05.9       | -22 30 48.9     | 36933     | 44  | 6.1 | fibr | 16859   | 30 |
| 25223  | 1 02 06.1       | -21 39 24.2     | 17623     | 75  | 2.8 | fibr |         |    |
| 25222  | 1 02 13.2       | -21 32 08.9     | 17473     | 55  | 6.1 | fibr |         |    |
| 25238  | 1 02 16.8       | -21 35 50.2     | 17548     | 56  | 5.5 | fibr |         |    |
| 25235  | 1 02 17.5       | -22 04 19.6     | 16732     | 39  | 7.4 | fibr |         |    |
| 25229  | 1 02 19.2       | -22 32 13.4     | 16285     | 33  | 8.3 | fibr |         |    |
| 25239  | 1 02 24.1       | -21 32 17.2     | 8010      | 18  | 5   | fibr |         |    |
| 25240  | 1 02 25.4       | -21 30 26.6     | 25827     | 65  | 4.0 | fibr |         |    |
| 25230  | 1 02 27.4       | -22 30 33.4     | 23611     | 80  | 4   | fibr |         |    |
| 25245  | 1 02 32.7       | -22 16 21.1     | 37378     | 56  | 4.5 | fibr |         |    |
| 25243  | 1 02 39.8       | -21 35 06.8     | 17486     | 44  | 6.4 | fibr |         |    |
| 25244  | 1 02 42.1       | -22 13 09.0     | 17034     | 51  | 6.6 | fibr |         |    |
| 25247  | 1 02 44.2       | -22 19 31.1     | 16845     | 31  | 9.5 | fibr | 16859   | 30 |
|        |                 |                 | 16896     | 51  | 5.7 | fibr |         |    |
| 25248  | 1 02 54.0       | -21 41 02.8     | 15279     | 74  | 3.7 | fibr |         |    |
| 25246  | 1 02 55.2       | -22 33 03.3     | 36938     | 37  | 3   | fibr |         |    |
| 25252  | 1 03 08.1       | -21 44 51.8     | 12112     | 24  | 4   | fibr | 12095   | 30 |
|        |                 |                 | 12047     | 40  | 7   | fibr |         |    |
| 25253  | 1 03 08.5       | -22 21 24.2     | 17206     | 28  | 11.4| fibr |         |    |
| 25254  | 1 03 18.3       | -21 47 43.0     | 31166     | 42  | 5   | fibr |         |    |
| 25256  | 1 03 20.1       | -21 27 59.6     | 8456      | 38  | 7.5 | fibr |         |    |

References for Table 2.

This paper: fibr = LCO fiber spectra; MK = Merrifield & Kent (1989); RC3 = de Vaucouleurs et al. (1991)
Table 3. 1D Statistics

| Cluster     | N     | $C_{BI}^a$  | $S_{BI}$ | skewness | kurtosis | asymmetry | tail$^b$ |
|-------------|-------|-------------|----------|----------|----------|-----------|----------|
| A119        | 153   | 13228 (+103,-98) | 778 (+122,-88) | 0.407    | 3.962    | 0.545     | 1.183    |
| A119 Group 1| 11    | 11699 (+151,-183) | 291 (+163,-83) | -0.712   | 2.797    | -0.826    | 1.046    |
| A119 Group 2| 125   | 13248 (+71,-76)  | 472 (+41,-36)  | -0.008   | 2.140    | -0.180    | 0.855    |
| A119 Group 3| 17    | 14707 (+281,-104) | 352 (+193,-152) | 0.923    | 2.666    | 0.459     | 1.222    |
| A133        | 120   | 16869 (+114,-114) | 735 (+87,-72)  | 0.140    | 2.708    | 0.025     | 0.969    |

$^a$Errors on $C_{BI}$ & $S_{BI}$ are bootstrapped at 90% confidence intervals for 10000 bootstraps.

$^b$Tail index has been normalized to a gaussian.
Table 4. 2 and 3D Statistics

| Cluster      | N_{gal} | V_{pec} | Z_{score}^a | L_{RAT} | Δ   | α   | ϵ   |
|--------------|---------|---------|-------------|---------|-----|-----|-----|
| A119         | 153     | -5      | 0.007 (+0.144, -0.142) | 1.456   | 0.077 | 1.639 | -4.718 |
| A119 Group 1 | 11      | -       | -           | -0.497  | -1.058 | 1.232 |
| A119 Group 2 | 125     | 34      | 0.072 (+0.171, -0.180) | 1.583   | -1.787 | 0.474 | 0.651 |
| A119 Group 3 | 17      | -       | -           | -0.704  | -0.757 | 0.934 |
| A133         | 120     | 191     | 0.260 (+0.166, -0.164) | 2.415   | 4.523 | 1.128 | 0.956 |
| A133(R<1.5h^{-1}Mpc) | 78 | -       | -           | 1.423   | -     | -    | -   |

^aErrors are bootstrapped at 90% confidence intervals for 10000 bootstraps.
Table 5. Mass Estimators

| Cluster | Group/Radius\(^a\) | N\(^\text{gal}\) | M\(_{\text{virial}}\)^b,c | M\(_{\text{pme}}\) | M\(_{\text{avg}}\) | M\(_{\text{med}}\) | M\(_{\text{xray\,vir}}\) |
|---------|---------------------|-----------------|-------------------------|-----------------|-----------------|-----------------|-----------------|
| A119    | Group 1\(^d\)       | 11              | 0.25 (0.06,1.55)         | 0.81 (0.35,1.32) | 0.70 (0.23,1.22) | 0.67 (0.18,0.98) | 1.00\(^e\)      |
| A119    | Group 2 R<0.5        | 30              | 1.62 (1.11,2.34)         | 1.78 (1.21,2.40) | 1.28 (0.84,1.69) | 1.21 (0.80,1.72) | 1.00\(^e\)      |
| A119    | Group 2 R<1.5        | 98              | 3.05 (2.38,3.87)         | 3.78 (3.02,4.59) | 2.97 (2.37,3.53) | 2.91 (2.22,3.47) | 11.58\(^f\)     |
| A119    | Group 2 R<2.3        | 125             | 4.00 (3.23,4.94)         | 5.05 (4.15,6.02) | 4.04 (3.33,4.72) | 3.82 (3.06,4.57) | 12.9\(^f\)      |
| A119    | Group 3\(^d\)        | 17              | 2.31 (1.02,5.08)         | 4.34 (1.54,7.80) | 3.199 (0.97,5.25) | 1.14 (0.30,2.93) | 2.36\(^f\)      |
| A133    | R<0.5               | 31              | 2.77 (1.71,4.37)         | 3.62 (2.01,5.49) | 2.65 (1.46,3.89) | 2.27 (1.20,3.43) | 7.09 (4.98,9.44) |
| A133    | R<1.5               | 78              | 7.79 (5.80,10.46)        | 10.97 (7.86,14.57) | 8.220 (5.96,10.63) | 7.09 (4.98,9.44) | 7.30\(^e\)      |
| A133    | R<2.4               | 120             | 11.28 (8.86,14.36)       | 14.87 (11.41,18.72) | 12.42 (9.71,15.13) | 10.78 (8.03,13.67) |                |

\(^a\)Masses are x10\(^14\) Solar Units. Errors are 90% boostrapped confidence intervals.
\(^b\)Radii are h\(^-1\)Mpc
\(^c\)Errors are bootstrapped at 90% confidence intervals for 10000 bootstraps.
\(^d\)These values must be taken in the context of infalling clumps, see the Mass section of Abell 119.
\(^e\)Jones 1996
\(^f\)Abramopoulos & Ku 1983, Table 5, R<1.93h\(^-1\)Mpc
Lee statistic for Abell 133

\( \phi \) (rads) vs. \( \lambda \)
