New measurements of radial velocities in clusters of galaxies-V**,**

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ABSTRACT

As a part of our galaxy-cluster redshift survey, we present a set of 79 new velocities in the 4 clusters Abell 376, Abell 970, Abell 1356, and Abell 2244, obtained at Haute-Provence observatory. This set now completes our previous analyses, especially for the first two clusters. Data on individual galaxies are presented, and we discuss some cluster properties. For Abell 376, we obtained an improved mean redshift $\bar{z} = 0.04750$ with a velocity dispersion of $\sigma_V = 860$ km s$^{-1}$. For Abell 970, we have $\bar{z} = 0.05875$ with $\sigma_V = 881$ km s$^{-1}$. We show that the A1356 cluster is not a member of the “Leo-Virgo” supercluster at a mean redshift $\bar{z} = 0.112$ and should be considered just as a foreground group of galaxies at $\bar{z} = 0.0689$, as well as Ab1435 at $\bar{z} = 0.062$. We obtain $\sigma_V = 0.09962$ for Abell 2244 with $\sigma_V = 965$ km s$^{-1}$. The relative proximity of clusters A2244 and A2245 ($\sigma_2 = 0.08738$, $\sigma_{25} = 992$ km s$^{-1}$) suggests that these could be members of a supercluster that would include A2249; however, from X-ray data there is no indication of interaction between A2244 and A2245.

Key words. galaxies: distances and redshifts – galaxies: cluster: general – galaxies: clusters: individual: Abell 376 – galaxies: clusters: individual: Abell 970 – galaxies: clusters: individual: Abell 1356 – galaxies: clusters: individual: Abell 2244

1. Introduction

Redshift surveys in clusters of galaxies are needed to study their dynamical and evolutionary state. In clusters, the mean velocity is a key factor in deriving distances, allowing the study of matter distribution on very large scales. Within clusters analysis of the velocity field can lead to an estimate of the virial mass, constraining models of the dark matter content. Galaxy velocity measurements provide informations that are complementary to other wavelengths, in particular what are obtained through X-ray observations of clusters. Optical, spectroscopic, and X-ray data form basic pieces of information for the mass estimates. However, discrepancies between these estimators are often found (e.g. Girardi et al. 1998; Allen 2000; Cypriano et al. 2005). Virial mass estimates rely on the assumption of dynamical equilibrium. X-ray mass estimates also depend on the dynamical equilibrium hypothesis and on the still not well-constrained intracluster gas temperature gradient (e.g., Leccardi & Molendi 2008). Finally, mass estimates based on gravitational lensing are considered more reliable than the others (e.g., Mellier 1995) because they are completely independent of the dynamical status of the cluster. The drawback is that lensing can only probe the central region of clusters. The discrepancies among the methods may come from the non-equilibrium effects in the central region of the clusters (Allen 1998).

In this paper, we complete our preceeding studies of the dynamical status of the two clusters Abell 376 (Proust et al. 2003) and Abell 970 (Sodré et al. 2001; Lima Neto et al. 2003) with the addition of 46 and 14 galaxies, respectively. The observations of radial velocities reported here are part of a program to study the dynamical structure of clusters of galaxies, which was started years ago and which had several already published analyses (see e.g. Proust et al. 1992, 1995, 2000; Capelato et al. 1991, 2008, and references above).

We have added only 10 galaxies in each of the two clusters Abell 1356 and Abell 2244 since a larger set of velocities in these two clusters have been obtained in the course of the Sloan Digital Sky Survey (SDSS)¹. For that reason spectroscopic observations were no longer pursued in these two clusters.

We present in Sect. 2 the details of the observations and data reduction. In Sect. 3 we discuss the distribution and the velocity analysis of the cluster galaxies, and we summarize our conclusions for each cluster. We adopt here, whenever necessary, $H_0 = 70$ km s$^{-1}$ Mpc$^{-1}$, $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$.

2. Observations and data reductions

The new velocities presented in this paper were obtained with the 1.93m telescope at Haute-Provence Observatory. Observations were carried out in April 2000, May 2001 and January 2005. We used the CARELEC spectrograph at the Cassegrain focus, equipped with a 150 line/mm grating blazed at 5000 Å and coupled to an EEV CCD detector 2048 x 1024 pixels with a pixel size of 13.5 μm. A dispersion of 260 Å/mm was used, providing spectral coverage from 3600 to 7300 Å. Wavelength calibration was done using exposures of He-Ne lamps.

¹http://www.sdss.org/
The data reduction was carried out with IRAF\textsuperscript{2} using the LONGSLIT package. Radial velocities were determined using the cross-correlation technique (Tonry & Davis 1979) implemented in the RVSAO package (Kurtz et al. 1991; Mink et al. 1995) with radial velocity standards obtained from observations of late-type stars and previously well studied galaxies.

A total of 79 velocities was obtained from our observations. Table 1 lists positions and heliocentric velocities for individual galaxies with the following columns:

1. number of the object. For A376, this number refers to Dressler (1980) and for A970 it continues the list of Sodré et al. (2001);
2. right ascension (J2000);
3. declination (J2000);
4. morphological type either from Dressler’s (1980) catalog for A376 and from a visual inspection on the Palomar Sky Survey (POSS) for A970;
5. heliocentric radial velocity with its error in \( \text{km s}^{-1} \);
6. \( R \)-value derived from Tonry & Davis (1979);
7. notes.

We searched in the NED database\textsuperscript{3} for additional velocities to complement our redshift sample. As mentioned before, the fields of A1356 and A2244 are within the sky coverage area of the Sloan Digital Sky Survey, and because of that most of the 20 measurements made for these clusters resulted in duplicated data: only 5 new redshifts could have contributed to A1356 and none for A2244. This last cluster was studied by Rines & Diaferio (2006) using the caustics technic (Diaferia 1999) to remove interlopers and to estimate the velocity dispersions within \( r_{200} \). We have no more information to add to their work.

For already observed galaxies, velocity comparison was made between our data set and NED. We obtained \( (V_o - V_{red}) = 31 \text{ km s}^{-1} \), the standard deviation of the difference being 67 \( \text{km s}^{-1} \). These results are consistent with the errors of Table 1. The velocities in the present study agree with those previously published within the 2\( \sigma \) level.

### 3. Galaxy distribution and kinematical analysis

#### 3.1. Abell 376

When including previous measurements (Proust et al. 2003, hereafter P03), there is a total of 113 measured velocities in the field of Abell 376, from which 40 are new ones. Note that galaxies from our redshift sample were selected from the morphological sample of A376 by Dressler (1980), being almost complete (113 out of 120). As in P03, galaxy photometry were provided by the POSS I Revised APS Catalogue\textsuperscript{4} (Cabanela et al. 2003) which gives integrated magnitudes in the blue photographic \( O \) band. Figure 1, which is equivalent to Fig. 1 of P03, shows the projected distribution of galaxies in the field of Abell 376, where galaxies with measured redshifts have been identified.

\textsuperscript{2} IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

\textsuperscript{3} The NASA/IPAC Extragalactic Database (NED) is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

\textsuperscript{4} The POSS-I Revised APS Catalogue is available at the MAPS database from the University of Minnesota, at http://aps.umn.edu/
Table 1. Continued.

| Galaxy id | RA (2000) | Dec (2000) | Type | Hel. Vel. | $R$ | $N$ |
|-----------|-----------|------------|------|-----------|-----|-----|
| A1356     |           |            |      |           |     |     |
| 1         | 11 42 04.84 | +10 21 49 | S    | 6295 43   | 5.19 | 114 |
| 2         | 11 42 08.7  | +10 27 19 | S    | 21 030 82 | 3.63 |     |
| 3         | 11 42 15.3  | +10 26 50 | E    | 35 166 27 | 11.75| 115 |
| 4         | 11 42 22.3  | +10 44 19 | S    | 23 753 45 | 8.93 | 116 |
| 5         | 11 42 23.7  | +10 26 09 | E    | 21 474 54 | 6.96 | 16 129|
| 6         | 11 42 24.4  | +10 40 04 | S    | 23 794 79 | 6.70 | 117 |
| 7         | 11 42 29.6  | +10 29 24 | S    | 20 910 75 | 6.27 |     |
| 8         | 11 42 29.7  | +10 28 31 | S0   | 20 702 51 | 10.56| 118 |
| 9         | 11 42 31.7  | +10 25 24 | S    | 10 655 75 | 5.61 | 17 130|
| 10        | 11 42 43.4  | +10 31 00 | E    | 36 132 74 | 3.62 | weak 131 |

Notes. Data from NED:

- Galaxy was studied to the same central region as was studied in P03 (see Fig. 1), the completeness level increases to a maximum of 67% at 18 mag, which is more acceptable. In view of this, we restrain the kinematical analysis to the same central region as was studied in P03. Moreover, as discussed in P03, despite its incompleteness, the 19.5 mag sample was found to be representative of the spatial distribution of galaxies in the central region of the cluster. This allows a more detailed kinematical analysis of central region of the cluster.

We used the ROSTAT routines (Beers et al. 1990; Bird & Beers 1993) to analyze the velocity distribution of our sample.

We applied the method of the weighted gap analysis as discussed by Ribeiro et al. (1998; see also Capelato et al. 2008) in order to remove interlopers and to identify the main kinematical structures. Figure 2 (inset) shows the radial velocity distribution of the whole redshift sample, where the presence of a very dominant kinematical structure is confirmed by the gap analysis. This kinematical structure, which we identify for A376, is displayed in the main part of Fig. 2. It is constituted of 89 galaxies with radial velocities ranging between 12 500 and 16 300 km s$^{-1}$, with mean $V_{\text{rec}} = 14 241^{\pm 151}$ km s$^{-1}$, corresponding to redshift $z_{A376} = 0.04750$. The velocity dispersion corrected following Danese et al. (1980) is $\sigma_{\text{corr}} = 830^{\pm 122}$ km s$^{-1}$.

The ROSTAT routines detect a significant gap (indicated by an arrow in Fig. 2) $\Delta V \sim 100$ km s$^{-1}$ in the velocity distribution sample at $V_{\text{gap}} = 14 500$ km s$^{-1}$ (3% probability of being drawn from an underlying normal distribution). To see if this reflects some special feature of the galaxy distribution, in Fig. 3 (left panel) we show the kernel weighted local mean velocity map for galaxies belonging to the kinematical structure shown in Fig. 2, together with their adaptative kernel projected density map.

As seen from this figure, the high-velocity galaxies, $V \gg V_{\text{gap}}$, are almost completely concentrated to the north of the cluster center, characterizing an SW-NE velocity gradient, possibly caused by a substructure being accreted by the main cluster. This

\[5\] In this paper means and dispersions are given as biweighted estimates, see Beers et al. (1990). Error bars are 90% confidence intervals and are calculated by bootstrap re-sampling of 10 000 subsamples of the velocity data.
Fig. 2. The radial velocity distribution for the Abell 376 sample of galaxies between 12 000 and 18 000 km s$^{-1}$ contained in the central region indicated in Fig. 1. The dashed line curve shows the Gaussian distribution corresponding to the mean velocity and velocity dispersion quoted in the text (normalized to the sample size). The inset shows the distribution for the entire sample of 113 redshifts in the region of A376 (dotted line histogram in the main figure). The arrow indicates the position of a gap in the velocity distribution (see text). The shaded histograms show the radial velocity distributions of the E$+$S0 galaxies (left-handed shade; red lines) and for the S$+$I galaxies (right hand shade; blue lines).

Fig. 3. Contours of equal local mean velocity (left panel) and of local mean dispersion velocity (right panel), superimposed on the gray-level AK surface density image of the central region indicated in Fig. 1. Higher values are shown with red continuous lines: $\overline{V}_{\text{rec}}$ ($\Delta = 200$ km s$^{-1}$) between 14 500 and 15 500 km s$^{-1}$ (left) and $\overline{\sigma}$ ($\Delta = 100$ km s$^{-1}$) between 900 and 1600 km s$^{-1}$ (right); lower values with blue dotted lines: $\overline{V}_{\text{rec}}$ between 12 500 and 14 300 km s$^{-1}$ (left) and $\overline{\sigma}$ between 400 and 800 km s$^{-1}$ (right). The bold black line in the left panel is the boundary of the region where results are 3$\sigma$-significant after 10 000 bootstraps of the data. All samples are limited at 19.5 mag.

suggests that the velocity distribution is bimodal. Indeed, the normality tests of ROSTAT already indicate that the distribution is assymetrically tailed, as is also apparent in Fig. 2. Figure 4 shows the local mean velocity profile taken along the line of highest gradient. As seen, the velocity gradient only manifests itself outside the core region of A376, which displays a uniform mean velocity, very nearly the same as the E/D dominant galaxy (indicated by the left arrow). This is interesting because, as noted in P03, when compared to the cluster baricenter, the peculiar velocity of the dominant galaxy (322 km s$^{-1}$) is only barely consistent with the distribution of peculiar velocities of cD galaxies given by Oegerle & Hill (2001). Our new analysis suggests that A376 is a far more complex structure in which only the main central core seems to conform to the properties of a (classical) relaxed cluster, thought to be centered on a large dominating spheroidal galaxy at rest relative to it.

Considering the velocity distribution of galaxies accordingly to their morphological types, Fig. 2 shows the velocity distribution of early type (E+S0: 61 objects) and late type (S+I: 28 objects) galaxies, according to the classification given by Dressler (1980). Both samples are limited at 19.5 mag. Their mean velocities and velocity dispersions are $\overline{V}_{\text{early}} = 14 378 \pm 167$ km s$^{-1}$ and $\sigma_{\text{early}} = 716^{+333}_{-36}$ km s$^{-1}$, and for S+I types $\overline{V}_{\text{late}} = 13 849^{+381}_{-390}$ km s$^{-1}$, $\sigma_{\text{late}} = 966^{+316}_{-295}$ km s$^{-1}$. As observed in most clusters (Sodré et al. 1989; Stein 1997; Carlberg et al. 1997; Adami et al. 1999), the velocity dispersion of the late-type population is larger than that of the early-type population. The results obtained in P03 remain unchanged with these new data.

To examine the relative contribution of early and late type galaxies to the overall projected distribution of galaxies, we show the high and low density isopleths of their distributions in Fig. 5 (left and right panels, respectively) superimposed on the AK surface density image of the photometric sample, limited at 19.5 mag. Early type galaxies are largely dominant over late-type galaxies by more than a factor 2 in number. As seen from this figure, they are also much more concentrated (dense) in the center of the cluster, by a factor $\sim 6$. This is a clear demonstration...
Fig. 4. The local mean velocity profile (upper panel) and the local dispersion velocity profile (lower panel) taken along a line showing the highest velocity gradient (equation given in the lower panel). The arrows indicate the position and velocity of the dominant E/D central cluster galaxy: lower and upper arrows for the RA and Dec positions and the left upper arrow for its velocity. Error bars are 1-σ standard deviation of mean values after 5000 data bootstraps.

Fig. 5. Isopleths of the surface distribution of early (E+S0) galaxies (continuous lines) and late (S+I) galaxies (dotted lines) superimposed on the AK surface density image of the central region of Fig. 1. Left panel: low-density isopleths $\Sigma_5 < 1.4$, $\Delta_5 = 0.35$. Right panel: high-density isopleths $8.3 > \Sigma_5 > 1.4$, $\Delta_5 = 1.38$. $\Sigma_5$ is measured in units of $10^{-5}$ gal arcsec$^{-2}$.

3.2. Abell 970

This cluster is extensively discussed in Sodré et al. (2001, hereafter S01) and in Lima Neto (2003), which have shown that this is a rather complex system. Including the already published velocities (S01), 14 new redshifts for a total of 83 have been obtained in the direction of Abell 970.

As already done in S01, both the iterative gap analysis and the statistical tests provided by ROSTAT were applied to remove contaminant interlopers in the redshift sample. This has shown that the cluster radial velocities range between $\sim 15 000$ km s$^{-1}$ and $20 000$ km s$^{-1}$, with mean and dispersion velocities $V_{\text{rec}} = 17 612^{+180}_{-182}$ km s$^{-1}$ ($z_{\text{clus}} = 0.05875$) and $\sigma = 881^{+144}_{-123}$ km s$^{-1}$. The histogram of the velocity distribution is displayed in Fig. 6.

These analyses have also shown a significant gap in the velocity distribution, $V_{\text{gap}} \sim 18 500$ km s$^{-1}$, already reported by S01 (see Fig. 6). In that work it was suggested that the gap occurred because of the bimodality of the radial velocity distribution, signaling the state of non equilibrium of the cluster, also proven by the presence of very compact clump of galaxies situated $\sim 8$ arcmin ($544 h_{70}^{-1}$ Kpc at $z = 0.059$) NW of the BCG with mean velocity $V_{\text{clump}} = 19 227$ km s$^{-1}$. The new data presented here reinforces this picture, since the new redshifts distribute everywhere outside the central $\sim 1$ Mpc region of the cluster. The off-set of the X-ray emission distribution relative to the galaxy distribution and the gas temperature and metal abundance gradients are also strong evidence that A970 has suffered a recent merger with a subcluster or that the NW substructure has
recently passed through the center of A970 (see Lima Neto et al. 2003, for details).

### 3.3. Abell 1356

Abell 1356 was classified as a Bautz-Morgan II-III morphology and richness class \( R = 1 \) (Abell et al. 1989), at redshift \( z = 0.0698 \) (Struble & Rood 1999) based only on two velocities. Up to now, the cluster has not been studied except by X-ray observations. A1356 is within the sky area surveyed by the SDSS project which thus provides data, both spectroscopic as photometric, and allowing detailed studies. As seen in Table 1, 8 of the 10 redshift measurement we undertook in the field of A1356 have also being targeted by SDSS.

Jones & Forman (1999) analyzed the Einstein IPC X-ray image of A1356. The count rate is 0.0065 s\(^{-1}\) in a region of \( 1 h_{70}^{-1} \) Mpc radius giving a luminosity \( L_X = 0.429 \times 10^{44} \text{ erg cm}^{-2} \text{s}^{-1} \) in the [0.5–4.5] keV band (notice that they adopted the redshift of \( z = 0.1167 \), based on Struble & Rood 1987). They did not detect any cooling-flow and they were not able to derive any isocontour map of the X-ray emission.

An analysis of A1356 using ROSAT data was done by Romer et al. (2000) in the context of the SHARC survey. They obtained a total flux \( f_X = 51.82 \times 10^{-14} \text{ cm}^{-2} \text{s}^{-1} \) in the [0.5–2.0] keV passband, which corresponds to a luminosity \( L = 0.11 \times 10^{43} \text{ erg s}^{-1} \) assuming a temperature of 2 keV. ROSAT PSPC observations have also been analyzed by Burke et al. (2003), also as part of the SHARC survey. They find that A1356 has a flux \( f_X = 57.51 \times 10^{-14} \text{ cm}^{-2} \text{s}^{-1} \) in the [0.5–2.0] keV passband and luminosities \( L_X = 0.12 \times 10^{44} \text{ erg s}^{-1} \) in the [0.5–2.0] keV and \( L_X = 0.22 \times 10^{44} \text{ erg s}^{-1} \) in the [0.3–3.5] keV bands. Both these analyses of ROSAT data were done in an automatic way as part of their pipeline for identifying distant cluster candidates.

Figure 7 shows the redshift distribution of galaxies within a square region of side 0.83\(^\circ\) centered on the nominal center of A1356 (\( 11^h42^m28.8^s + 10^d26^m21^s \)); a step corresponds to 500 km s\(^{-1}\). The most significant kinematical structures identified with gap analysis are indicated by different symbols within dashed vertical lines. The bar code at the top of the plot shows the redshift coordinate of the entire sample.

### Table 2. Kinematical groups projected in the field of A1356.

| ID | Redshift range | \( z \) | \( \sigma \) (km s\(^{-1}\)) | No. of gal |
|----|----------------|---|-----------|----------|
| A  | \( 0.020 < z < 0.022 \) | 0.02053 | 155\(_{+46}^{+199} \) \(_{-59}^{+1} \) | 15 |
| B1 | \( 0.067 < z < 0.072 \) | 0.06988 | 384\(_{+156}^{+186} \) \(_{-159}^{+1} \) | 12 |
| B2 | \( 0.078 < z < 0.081 \) | 0.07932 | 253\(_{+149}^{+199} \) \(_{-174}^{+1} \) | 7 |
| C1 | \( 0.102 < z < 0.108 \) | 0.10485 | 524\(_{+38}^{+199} \) \(_{-54}^{+1} \) | 29 |
| C2 | \( 0.115 < z < 0.122 \) | 0.11761 | 475\(_{+86}^{+169} \) \(_{-49}^{+1} \) | 56 |
| C3 | \( 0.126 < z < 0.128 \) | 0.12688 | 63\(_{+38}^{+1} \) \(_{-22}^{+1} \) | 8 |
| D  | \( 0.149 < z < 0.155 \) | 0.15210 | 491\(_{+123}^{+130} \) \(_{-117}^{+1} \) | 25 |

Figure 8 shows the projected positions of galaxies in this same region. As seen, galaxies belonging to B1 seem to constitute an elongated SE-W structure, concentrated around the nominal center of A1356. This confirms the reality of this system, although not as a rich cluster of galaxies as it was initially believed, but probably just as a sparse group. The hypothesis that the two kinematical groups could belong to one single structure, with the detected gaps interpreted as due to the incompleteness...
of 8 Abell clusters, 6 of them with “known distances”: A1341 ($z = 0.1049$), A1342 ($z = 0.1061$), A1345 ($z = 0.1095$), A1354 ($z = 0.1178$), A1372 ($z = 0.1126$), and A1356 ($z = 0.117$); and 2 other clusters with only “estimated” distances, A1379 and A1345. However, our analysis above pointed out that A1356 should be considered as just a foreground group of galaxies, located at $z = 0.0689$, thus giving no contribution to the Leo-Virgo supercluster. In fact, the field around A1356 seems highly contaminated by background galaxies, with a substantial fraction of them belonging at redshifts of the Leo-Virgo supercluster (groups C1, C2, and probably C3 of Table 2), and this should be the reason for the erroneous description of the cluster. Note that the cluster A1435 has a redshift $z = 0.062$ (NED) and should also be considered as a foreground cluster.

The ROSAT PSPC X-ray image is rather shallow, with an exposure time of 11.7 ks, but it should detect an Abell cluster. To verify that indeed the PSPC could detect extended diffuse emission from a cluster up to $z = 0.1$, we selected another Abell cluster that was observed by the PSPC with similar conditions, Abell 2034. It is a $z = 0.115$ cluster classified as a II-III B-M class and richness class 2. Although it is somewhat richer than A1356 (which is classified as richness class 1), it was observed with a shorter exposure time, 8.9 ks compared to 11.7 ks for A1356. We constructed an image for each cluster in exactly the same way and show them in Fig. 11. The difference is striking, so we can conclude that there is no sign of diffuse emission from A1356. If the redshift of A1356 is indeed $< 0.07$, as we pointed out above, rather than $< 0.11$, the discrepancy between the images would be even stronger.

### 3.4. Abell 2244

Abell 2244 has a I-II morphology in the Bautz-Morgan classification and a richness class $R = 2$ (Abell et al. 1989). It is a cD or D-galaxy dominated cluster, and its brightest cluster galaxy has an absolute magnitude of $-22.0$ and a diameter of 98 kpc at the 25 Vmag arcsec$^{-2}$ isophote (Schombert et al. 1989). These authors give a redshift $\pm 0.0968 \pm 0.0008$ with a dispersion $\sigma = 0.00414$. They note the presence of a very near companion to the cD galaxy at a distance of 3 arcsec (4 kpc) and a velocity difference 50 km s$^{-1}$, which could be a final stage of merging. They also suggest a subclustering in the line of sight from a set of 18 pairs of galaxies where only one is bound. A second structure has been evidenced by Miller et al. (2005) at a redshift $z = 0.1024$.

The wedge diagrams in RA and Dec of the 417 velocities collected in a 40 arcmin radius (4.64 Mpc) from the NED database completed with our results are displayed in Fig. 12. The positions of the two clusters A2244 and A2245 are represented with ellipses of 3 Mpc in radius perpendicular to the line of sight and 1000 km s$^{-1}$ in radius along the l.o.s. Instead of a double cluster as quoted by Struble & Rood (1999), the two clusters belong to a much larger structure visible in RA and Dec at an average velocity of 28 500 km s$^{-1}$, which is associated to a supercluster by Einasto et al. (2001), including A2249. The velocity histogram of Fig. 13 shows 2 main peaks corresponding to the main velocities of A2244 and A2245. From the galaxies contained in each ellipse of Fig. 12 we obtain $C_{BI} = 29 867^{+780}_{-580}$ km s$^{-1}$ and $S_{BI} = 965^{+36}_{-66}$ km s$^{-1}$ (110 galaxies) for A2244 and $C_{BI} = 26 197^{+102}_{-100}$ km s$^{-1}$ and $S_{BI} = 992^{+57}_{-75}$ km s$^{-1}$ (94 galaxies) for A2245. Rines & Diaferio (2006) obtained for the same clusters respectively $\overline{v} = 29 890$ km s$^{-1}$, $\sigma = 981^{+74}_{-78}$ km s$^{-1}$ and $\overline{v} = 26 022$ km s$^{-1}$, $\sigma = 952^{+89}_{-70}$ km s$^{-1}$ respectively. For
both clusters, there is a very good agreement with Rines & Diaferio (2006), who calculate the velocity dispersion profile within about \( r_{200} \) following Danese et al. (1980). Note also the presence of two foreground structures with prominent peaks at 11 191 km s\(^{-1}\) and 18 461 km s\(^{-1}\).

Abell 2244 was observed in X-rays by Chandra (Donahue et al. 2005). It is nearly isothermal with \( kT = 5.5 \pm 0.5 \) keV at every radius < 4 arcmin. Figure 14 shows the gri Sloan image and the Chandra contours in the central part of A2244. A small offset between the center of the cD galaxy and the X-ray peak
is visible as a sharp edge on the X-ray image (a cold front or a shock front) about 10 arcsec NE from the center, possibly indicating a movement in that direction. Quoting Donahue et al. (2005), there is no evidence in the X-ray surface brightness map for fossil X-ray cavities produced by a relatively recent episode of AGN heating. No interaction seems to be present between A2244 and A2245.

4. Summary

In this paper we presented a set of 80 new radial velocities in the direction of 4 Abell clusters of galaxies: Abell 376, Abell 970, Abell 1356, and Abell 2244.

For A376 we obtained an improved mean velocity value $\bar{V}_{\text{rec}} = 14241$ km s$^{-1}$ and velocity dispersion $\sigma = 830$ km s$^{-1}$. The new data suggest that A376 displays a complex structure with evidence of bimodality in the radial velocity distribution where only the main central core seems to conform to the expected features of a relaxed cluster. The effect of morphological segregation acting locally in the cluster is clearly seen both in the surface distribution of galaxies and in their radial velocity distribution.

For A970, we have $\bar{V}_{\text{rec}} = 17612$ km s$^{-1}$ and $\sigma = 881$ km s$^{-1}$. Previous analyses have shown that the cluster has substructures and is out of dynamical equilibrium. The new data presented here confirms this conclusion.
We analyze the cluster A1356 for the first time. We derive a new velocity value \( V_{\text{rec}} = 20,986 \) km s\(^{-1}\) with \( \sigma = 384 \) km s\(^{-1}\). This cluster would not be a member of the “Leo-Virgo” supercluster as well as the cluster A1435 at \( V_{\text{rec}} = 18,588 \) km s\(^{-1}\).

We obtain for A2244 \( V_{\text{rec}} = 29,867 \) km s\(^{-1}\) and \( \sigma = 965 \) km s\(^{-1}\) and for A2245 \( V_{\text{rec}} = 26,197 \) km s\(^{-1}\) and \( \sigma = 992 \) km s\(^{-1}\). These two clusters are members of a possible supercluster including A2249. From optical and X-ray data, these A2244 and A2245 show no sign of interaction.

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