MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO DE PESQUISAS ESPACIAIS

AUTORIZAÇÃO PARA PUBLICAÇÃO
AUTHORIZATION FOR PUBLICATION

PALAVRAS CHAVES/KEY WORDS

CLUSTERS OF GALAXIES;
REDSHIFTS

AUTORIZADA POR/AUTHORIZED BY

Volker W.J.H. Kirchhoff
Director Space Atmos. Sci.

AUTOR RESPONSAVEL / RESPONSIBLE AUTHOR

Heinz Andernach

DISTRIBUIÇÃO/DISTRIBUTION

- [ ] INTERNA / INTERNAL
- [X] EXTERNA / EXTERNAL
- [ ] RESTRITA / RESTRICTED

REVISADA POR / REVISED BY

Osmar Pinto Júnior
Editor Space Atmos. Sci.

CDU/UDC: 524.45

DATA / DATE: setembro 1990

PUBLICAÇÃO Nº / PUBLICATION NO: INPE-5144-PRE/1632

ORIGEM / ORIGIN: DAS

PROJETO / PROJECT: RADIO

Nº DE PAG. / NO OF PAGES: 08

ULTIMA PAG. / LAST PAGE: 07

VERSÃO / VERSION:

Nº DE MAPAS / NO OF MAPS:

TÍTULO/TITLE

REDSHIFTS OF A THOUSAND ABELL CLUSTERS

AUTORES/AUTHORSHIP

Heinz Andernach

RESUMO-NOTAS/ABSTRACT-NOTES

The all-sky 'ACO' catalogue of 4073 rich clusters of galaxies and 1175 southern poor or distant S-clusters has been searched for published redshifts. Data for 1059 of them were found and classified into various quality classes to reduce e.g. the problem of foreground contamination of redshifts. Taking the ACO selection criteria for redshifts, a total of 992 entries remain, 21% more than ACO. Redshifts for rich clusters are now virtually complete out to z = 0.05 in the north and 0.04 in the south. In the north the magnitude-redshift (m_{10}-z) relation agress with that of Kalinkov et al. (1985). For the southern rich clusters minor adjustments to the m_{10}-z relation of ACO are suggested, while for the S-clusters the redshifts are ~ 30% lower than estimated.

OBSERVAÇÕES/REMARKS

Published in Proc. Workshop 'Large Scale Structure and Peculiar Motions in the Universe', Rio de Janeiro, Brazil, May 22-27, 1989 (eds. D.W. Latham and L.N. da Costa).

REDSHIFTS OF A THOUSAND ABELL CLUSTERS

HEINZ ANDERNACH
Instituto de Pesquisas Espaciais, Depto. de Astrofísica
Caixa Postal 515, 12201 São José dos Campos SP, Brazil

ABSTRACT. The all-sky 'ACO' catalogue of 4073 rich clusters of galaxies and 1175 southern poor or distant S-clusters has been searched for published redshifts. Data for 1059 of them were found and classified into various quality classes to reduce e.g. the problem of foreground contamination of redshifts. Taking the ACO selection criteria for redshifts, a total of 992 entries remain, 21% more than ACO. Redshifts for rich clusters are now virtually complete out to z = 0.05 in the north and 0.04 in the south. In the north the magnitude-redshift (m_{10}-z) relation agrees with that of Kalinkov et al. (1985). For the southern rich clusters minor adjustments to the m_{10}-z relation of ACO are suggested, while for the S-clusters the redshifts are ∿ 30% lower than estimated.

1. INTRODUCTION

Recent completion of Abell's (1958) catalogue of northern rich clusters of galaxies over the entire sky (Abell et al. 1989 = ACO in what follows) stimulated to merge and update their available redshifts. An appreciable amount of redshifts can be obtained from various publications apparently unrelated to rich clusters. In section 2 the literature search and the necessary classification of encountered redshifts are described. We analyse the completeness of the present redshift data as function of distance in section 3 and possible adjustments to the magnitude-redshift relation in section 4. Some by-produts of our analysis are mentioned in section 5.

2. SEARCH FOR PUBLISHED REDSHIFT DATA

2.1. The Finder List of Clusters

The ACO catalogue comprises four different lists of clusters: the "old" northern clusters, the improved sky survey data for the latter clusters in the overlap zone ($-17^o < \delta < -27^o$), the

to appear in Proc. Workshop 'Large Scale Structure and Peculiar Motions in the Universe', Rio de Janeiro, Brazil, May 22-27, 1989 (eds. D.W. Latham and L.N. daCosta)

southern rich clusters and finally the S-clusters, which are too poor or too distant to fulfil the Abell criteria. These files were first completed with data from previously published compilations of northern cluster redshifts (see Struble and Rood, 1987a) and those with southern entries (e.g. Schmidt, 1986) which have been identified here with the new ACO clusters. A single list was prepared of all 5250 clusters, sorted in R.A.(1950). For the clusters in the overlap zone only the new southern data were used.

For each cluster the Abell radius R_A (= 3 Mpc h^{-1} with H_o = 50 h km s^{-1} Mpc^{-1}) was computed either from the measured redshift or the estimated one according to previously published best fits to the relation between the magnitude m_{10} of the tenth brightest cluster galaxy and the cluster redshift. For the clusters with m_{10} measured from the southern sky survey ($m_{10}S$) the relation (11) of ACO was used, while for the rest (i.e. the clusters north of $\delta = -17^o$) the $m_{10}N - z$ relations no. 10, 12 and 13 of Kalinkov et al. (1985) were used in their respective magnitude range. A value of $q_o = 0.1$ and no corrections to the m_{10}-z relations of the type proposed by Sarazin et al. (1982) were assumed at this stage. The resulting master catalogue of ACO clusters with positions, redshifts and Abell radii served as a finder list for the literature survey.

2.2. The Literature Search

The July 1988 diskette version of the catalogue of galaxy redshifts south of $\delta = -17^o$ (Fairall and Jones, 1988) with 6229 entries and 5565 redshifts served as the primary source of new cluster redshifts. A search program was written that checked each galaxy for its location within one or more adjacent Abell circles, computed the projected distance ratio (in units of R_A) and its logarithmic redshift offset $\Delta z \equiv \lg(z_{gal}/z_{cl})$ from the estimated value z_{cl}. To suppress redundant information, only the overlaps with clusters lacking redshifts and cases of $|\Delta z| > 0.3$ for the clusters with measured redshifts were inspected. A total of 88 new cluster redshifts resulted.

Then the list of references given by Fairall and Jones (1988) was searched for galaxies north of $\delta = -17^o$. Finally recent years papers on galaxy redshifts were surveyed applying the procedure of section 2.1 'by hand', occasionally cross-correlating three catalogues (e.g. for the papers quoting only the UGC/NGC/Mkn designation of the galaxies and no positions). The major sources of redshifts (sorted by the number of clusters) are

Abell et al. 1989	760	Colless and Hewett 1987	14
Fairall and Jones 1988	88	da Costa et al. 1989	13
Struble and Rood 1987a	34	Dressler and Shectman 1988	12
Schmidt 1986	30	Owen et al. 1988	11
Rhee and Katgert 1988	29	32 other papers	67

giving a total of 1059 cluster redshifts. Contrary to ACO this includes discordant redshifts (i.e. those far from the m_{10} - estimate) which have been flagged as described in section 2.3.

2.3. The Catalogue and the Redshift Classification
The full catalogue will be published elsewhere and contains cluster name, centre position, richness, distance and Bautz-Morgan classification, m_{10} (N or S), the redshift, its reference, one of the following quality classifications

' ' z measured is within factor 2 of the m_{10}-estimate,
':' z measured is within factor 2 to 4 of the m_{10}-estimate,
'*' z measured is outside the above range i.e. likely due to foreground or background objects,
'f' same as '*', but for a cluster that has foreground galaxies projected onto it, according to notes by Struble and Rood (1987b) and/or ACO,
'!' listed redshift is average of very discordant ones, indicating possible line-of-sight projections,
'?' listed redshift is single peripheral object, concordant within a factor of 2 from the estimate,

and finally the Abell radius, using $q_o = 0.1$.

Table 1 shows the distribution of redshift classes over the different cluster samples (N = northern clusters at $\delta > -17^o$; N = northern clusters in the overlap zone; R = southern rich and S = southern poor/distant clusters). The number of clusters with concordant redshifts (992) has increased by 170 (=21%) as compared to ACO.

Table 1. Number of redshift classes for cluster subsamples

z-Class	N	N_{ov}	R	S	Total
' '	578	56	117	142	893
':'	30	1	32	36	99
'*'	6	0	11	7	24
'f'	17	3	2	2	24
'!'	1	1	3	5	10
'?'	2	0	2	5	9
All	634	61	167	197	1059

3. COMPLETENESS OF CURRENT REDSHIFT DATA

The total fraction of clusters without measured redshifts (76% of the northern, 89% of the southern rich clusters and 81% of the entire ACO catalogue) still appears overwhelming. More edifying, however, is a look at the redshift completeness as function of distance, as displayed in figure 1. Redshifts classified as 'f' were counted as estimates. Redshifts are avaialable for 99% (82 out of 83) of the northern (Abell 1958) sample out to z = 0.05 and for 93% (43 of 46) of the southern rich ACO clusters out to z = 0.04. The faster decline in available redshifts for the southern clusters is largely due to the gap of 30 years between publication of the northern and southern catalogues, which is the main reason also for the virtual absence of redshift measurements of distant ($z \geq 0.15$) southern clusters.

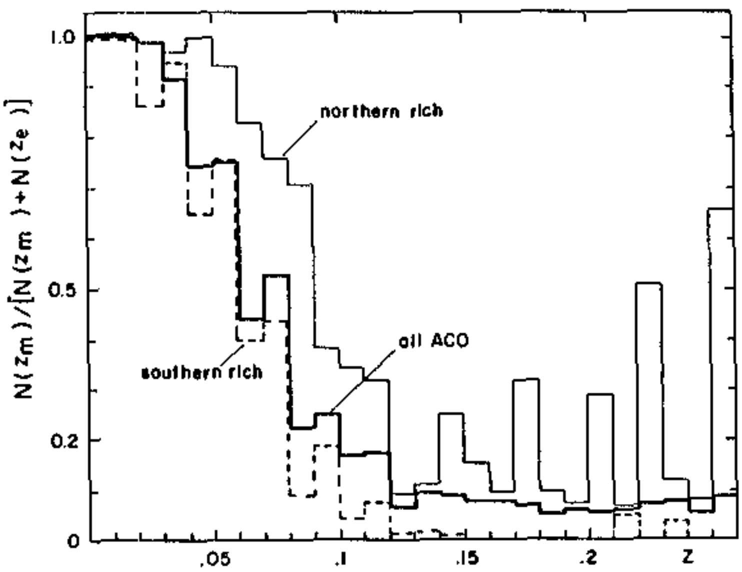

Figure 1. Fraction of clusters with measured redshifts as function of distance for different cluster subsamples

4. THE MAGNITUDE-REDSHIFT RELATION

As pointed out by ACO the magnitude scales for the tenth brightest galaxies are substantially different for the northern and southern sky surveys. Since these authors recommend the use of the southern magnitudes wherever available, the clusters were split into three subgroups to analyse the m_{10}-z relation:

- the clusters north of -17° declination (using $m_{10}N$)
- the southern rich clusters including the 'northern' ones in the overlap zone (using $m_{10}S$)
- the poor/distant S-clusters (again using $m_{10}S$).

Instead of trying an improvement of the photometric redshift calibration, only the histogram of logarithmic deviations Δz (cf. section 2.2) from the previously known calibration curves (section 2.1) has been constructed to look for systematic trends. For the northern clusters this histogram looks normally distributed around $\Delta z = 0$ with little excess for

$\Delta z < -0.3$ expected due to contamination by foreground redshifts. The data is thus in good agreement with the calibration of Kalinkov et al. (1985). The dispersion in Δz is $\sigma = 0.12$, only slightly higher than the value obtained with the sophistications applied by Sarazin et al. (1982).

However, the distributions for the southern rich and southern poor/distant S-clusters (see figure 2) show marked deviations from the redshift calibration proposed by ACO. For the rich clusters the histogram is again basically a normal distribution around zero with dispersion $\sigma = 0.12$. The peak itself, however, is shifted to $\Delta z \sim 0.05$. An inspection of the m_{10}-z plot reveals that this is due to the ACO calibration being to low and too flat for $14 < m_{10}S < 16$. Considering that the ACO calibration was based on only 30% of the present data, some adjustments were to be expected.

More surprising is that the measured redshifts for the S-clusters are on average 30% lower than the ACO estimate (assumed to be the same as for the rich clusters), without showing significantly larger dispersion ($\sigma \sim 0.13$). It is yet unclear, if this discrepancy is rather due to an excess foreground contamination of the redshifts or a systematic overestimate of $m_{10}S$ of the clusters caused by background contamination. A hint for the latter is the fact that 98% of the S-clusters of figure 2 have very low corrected galaxy counts of $C \leq 30$ and thus belong to the poorest of the sample.

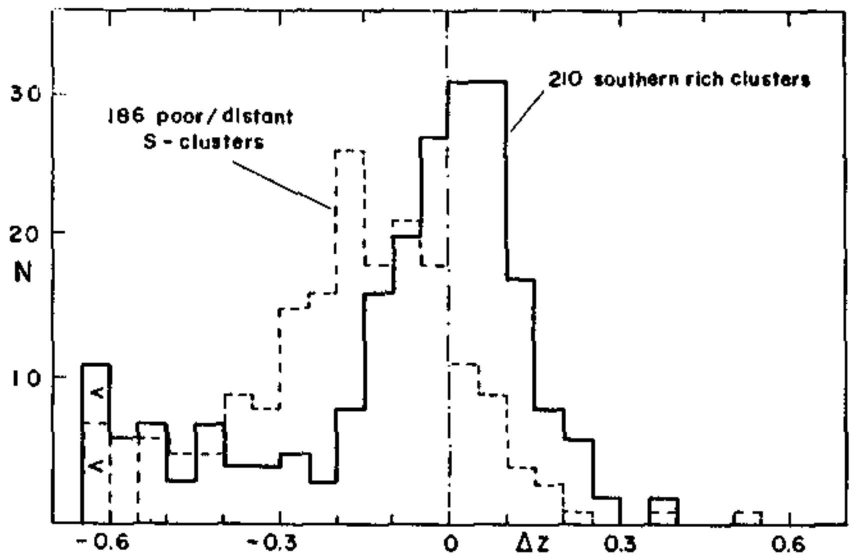

Figure 2. Histogram of logarithmic deviations of measured redshifts (excluding types *,!,?,f) from ACO's $m_{10}S$ calibration for two different subsamples of clusters.

At $\Delta z < -0.3$ both distributions show a much more pronounced tail than the northern clusters. This is very likely due to the use of a 'complete' redshift catalogue (Fairall and Jones 1988) only for the southern clusters, naturally yielding more foreground objects in the south.

Moreover, Table 1 shows that 20 clusters (= 77%) out of 26 northern ones with $|\Delta z| > 0.6$ are noted by Struble and Rood (1987b) to have background galaxies superimposed, while this is true for only 4 (= 18%) out of 22 southern clusters from the ACO notes. The latter authors thus seem to be much more cautious in claiming objects as foreground (cf. e.g. the notes on A14 in both papers). Extreme care is thus needed to establish improved m_{10}-z relations based on the present data. The fit procedure applied by Sarazin et al. (1982) might possibly be improved by weighting z with the number of galaxies contributing to each z.

5. MISCELLANEOUS

The analysis of the ACO catalogue yielded as a by-product certain features presumably yet unmentioned in literature.

While the original Abell catalogue does not have a single entry for $|b| < 10$, the ACO extension lists one rich cluster (A3627) and two poor ones (S610, S642) in this band.

The measured or estimated Abell radii were used to sum up the solid angle Ω subtended by all Abell circles of the different cluster samples. Table 2 lists for each sample the fraction of sky (f_{surv}) surveyed to find the clusters (subtracting the zone $|b| < 10^{\circ}$) as well as the fractional area $f_A = \Omega/f_{surv}/(4\pi$ sr) subtended by all clusters of a subsample. N is the surface density of the respective cluster subsample.

Table 2. Total area of Abell circles for the subsamples

	$\Omega/^{\square}$	$f_{surv}/\%$	$f_A/\%$	N/sr
northern rich	834	66.9	3.0	323
southern rich	575	28.6	4.9	456
southern poor	1005	28.6	8.5	327
all	2414	82.6	7.1	506

These numbers must be regarded as upper limits due to (a) the overestimate of Abell radii for foreground-contamined redshifts and (b) the non-correction for occasional overlap of clusters. There is, however, a significant difference in f_A and N between the northern and southern rich samples, probably due to both, the deficiency of the northern catalogue in its southern-most zones (see ACO) and the superior quality of the southern sky survey plates.

6. ACKNOWLEDGEMENTS

Drs. H.J. Corwin Jr. and A.P. Fairall kindly provided their diskette catalogues of rich clusters and southern galaxy redshifts prior to publication . I thank Dr. H.V. Capelato for letting me share the time for his presentation during the conference and Dr. J.E. Steiner for a critical reading of the text. I am grateful to Dr. D. Nunes for generous help in computer access and use.

7. REFERENCES

Abell, G.O. 1958, Ap. J. Suppl., 3, 211
Abell, G.O., Corwin, H.G., Olowin, R.P. 1989, Ap.J.Suppl.,70, 1
Ciardullo, R., Ford, H., Harms, R. 1985, Ap. J., 293, 69
Colless, M., Hewett, P. 1987, M.N.R.A.S., 224, 453
da Costa L., N., Pellegrini, P.S., Willmer, C., de Carvalho, R., Maia, M. 1989, Astron. J., 97, 315
Dressler, A., Shectman, S.A. 1988, Astron. J., 95, 985
Fairall, A.P., Jones, A. 1988, Publ. Dep. Astron. Univ. Cape Town nr. 10
Kalinkov, M., Stavrev, K., Kuneva, I. 1985, Astron. Nachr., 306, 283
Owen, F.N., White, R.A., Thronson, H. A. 1988, Astron.J., 95, 1
Rhee, G.F.R.N., Katgert, P. 1988, Astr. Ap. Suppl., 72, 243
Sarazin, C.L., Rood, H.J., Struble, M.F. 1982, Astr.Ap., 108,L7
Schmidt, K.-H. 1986, Astron. Nachr., 307, 69
Struble, M.F., Rood, H.J. 1987a, Ap. J. Suppl., 63, 543
Struble, M.F., Rood, H.J. 1987b, Ap. J. Suppl., 63, 555

DISCUSSION

J. Primack: A comment first: Thanks! I'm sure that your compilation will be helpful to many of us. How can I get a copy?

H. Andernach: A few paper copies of the preliminary version are supplied at this meeting. A version of 5.25-in diskette is available on request. You are welcome to have the spare copy on diskette that I have with me.

D. Burstein: I have found electronic mail (e.g. BITNET) a very efficient way of distributing ASCII catalogs of up to ~7000 entries (80 characters per line). I would strongly encourage you to use this means of distribution if it is available to you.