THE ASTROPHYSICAL JOURNAL, 262:442–450, 1982 November 15

THE NEUTRAL HYDROGEN DEFICIENCY OF THE CLUSTER A262

RICCARDO GIOVANELLI
Arecibo Observatory[1]
MARTHA P. HAYNES[2]
National Radio Astronomy Observatory
AND
GUIDO L. CHINCARINI
University of Oklahoma, and European Southern Observatory

Received 1981 October 19; accepted 1982 May 19

ABSTRACT

Seventy-two galaxies in the spiral-rich cluster A262 have been observed in the 21 cm line at Arecibo of which 67 have been observed by us. The H I content of individual galaxies, as compared with that of a sample of isolated galaxies, depends on the distance from the core of the cluster; while pronounced H I deficiency is observed near the central parts, normal amounts of H I are observed in the cluster periphery. With the newly available redshifts, a revised set of dynamical parameters for the cluster are given.

Subject headings: galaxies: clusters of — intergalactic medium — radio sources: 21 cm radiation

I. INTRODUCTION

The cluster of galaxies A262 is one of the most conspicuous condensations in the larger scale aggregate known as the Pisces-Perseus supercluster. It has been extensively studied optically, in X-rays and in the radio continuum. It is a spiral-rich cluster, characterized by the presence of a central X-ray source, 3U 015+36, which appears concentric with the D galaxy NGC 708; in this context, A262 may bring to mind the X-ray emission observed in the M87 region of the Virgo cluster (Forman 1981). The distribution of galaxies and its morphological segregation have been studied by Kalloglyan (1972) and Melnick and Sargent (1977), while many optical redshifts have been provided by Moss and Dickens (1977), Gregory, Thompson, and Tifft (1981), and Fanti *et al.* (1981).

The wealth of spirals in this cluster, the presence of a centrally located X-ray source, and its relatively low redshift make A262 an attractive candidate to study the H I content of member galaxies, a parameter thought to be very sensitive to environmental conditions. Early attempts to observe a large enough number of galaxies in the cluster, in the 21 cm line, were made independently by the three of us (in one instance in collaboration with J. R. Fisher and F. N. Owen), with unsatisfactory results due to either limited sensitivity or strong radio interference, using the 100 m telescope of the Max-Planck-Institut für Radioastronomie in Effelsberg and NRAO's 300 foot (91 m) telescope at Green Bank. Thanks in particular to the advent of a new low noise receiver, the observations were successfully conducted to completion with the 305 m telescope of the Arecibo Observatory, and we present the results in this paper.

II. DATA

Table 1 lists the galaxies observed in the 21 cm line at Arecibo, in the region of sky outlined in Figure 2. These observations are part of a wider project presently reaching completion to observe more than 1000 galaxies in the Perseus supercluster. In the selection of the sample we were guided by a criterion based on the expected flux to be observed for a given galaxy, according to criteria described in § III*a*. For each galaxy in the region we estimated the amount of telescope time necessary to achieve a meaningful limit for its H I content, in case of nondetection, thus establishing priorities for our observing list. Limitations imposed by the nearness of the region surveyed to the northern declination limit of the 305 m telescope, associated with the well known degradation of the instrument's performance at high zenith angles, also played a role in our selection. Galaxies with a known redshift, relatively more abundant in the central parts of clusters, were of course favored, as a more effective investment of the observing time could be obtained for those. Our list contains only those objects for which a meaningful statement on the abundance of their H I content could be made.

A description of the observational equipment, data analysis techniques, and full presentation of the data will be given elsewhere. In this paper we shall concentrate mainly on the subject of H I deficiency of the cluster galaxies. For five objects, indicated in a note to

---

[1] The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, operated by Cornell University under contract with the National Science Foundation.

[2] The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under contract with the National Science Foundation.

TABLE 1

GALAXIES OBSERVED AT 21 CM IN THE A262 REGION

Source (1)	R.A. (2)	Decl. (3)	m (4)	Size (5)	Type (6)	Code[a] (7)	$V_\odot$ (km s^{-1}) (8)	Width (km s^{-1}) (9)	$\int S\,dv$ (Jy km s^{-1}) (10)	$\frac{M_{\rm H}/L}{M_\odot/L_\odot}$ (11)	*Def* (12)	*Def′* (13)
502−119	1$^{\rm h}$34$^{\rm m}$06$^{\rm s}$.0	31°43′47″	14.6	1′.20×0′.60	Sb	5	6617	340	4.90	0.34	−0.13	−0.16
502−121	1 35 13.0	32 14 17	15.7	1.70×0.20	Sc	7	5444	333	2.60	0.43	0.37	0.39
521−066	1 37 35.5	34 22 20	14.8	2.00×0.35	Sc	7	5502	397	15.09	0.75	−0.26	−0.22
521−073	1 41 39.4	37 26 43	13.6	0.80×0.45	Pec	10	5662	291	3.01	0.09	0.16	−0.07
503−015	1 42 23.5	31 48 53	15.6	1.00×1.00	Sc	7	10776	119	2.25	0.55	−0.03	+0.00
521−078	1 42 57.5	34 51 30	14.8	1.20×0.70	Sc/SBc	7	5653	265	4.47	0.42	−0.18	−0.16
522−001	1 43 27.5	36 12 38	13.5	2.20×1.60	Sb	5	4500	305	10.15	0.28	0.08	0.05
522−002	1 43 33.8	34 40 43	14.7	0.75×0.45	Sb pec	5	5548	265	3.27	0.27	−0.35	−0.37
522−004	1 44 21.0	35 18 50	12.9	3.30×0.70	Sab	4	4694	873	3.01	0.02	0.92	1.18
522−005	1 44 35.4	35 47 13	15.0	1.00×0.50	Pec	10	4847	306	0.56	0.08	0.98	0.84
522−006	1 44 49.9	34 46 27	15.0	0.90×0.90	Sc	7	5557	115	5.01	0.71	−0.48	−0.47
522−007	1 45 11.2	36 12 13	15.0	1.10×0.55	Sab	4	4662	352	2.03	0.23	0.12	0.44
522−012	1 46 25.1	35 59 33	15.7	0.90×0.35	S…	5	…	…	< 0.93	< 0.20	> 0.29	> 0.28
522−014	1 46 30.6	35 12 16	14.5	2.00×1.20	S0a	2	4141	499	3.97	0.30	0.24	0.22
522−017	1 47 37.7	36 07 25	13.3	1.40×1.40	S0	1	5147	…	< 0.25	< 0.01	> 0.90	> 1.00
522−018	1 47 37.8	35 06 47	15.7	1.00×0.60	Dw sp	9	5497	192	3.91	1.06	−0.22	−0.21
522−020	1 47 49.1	35 02 15	13.3	2.60×1.70	Sb	5	4144	379	11.08	0.25	0.18	0.15
522−021	1 47 51.8	35 41 07	15.1	1.70×0.50	Sa	4	4889	…	< 0.50	< 0.07	> 1.02	> 1.18
522−024	1 48 33.1	35 49 06	14.5	0.90×0.60	Sb pec	5	5312	273	1.51	0.10	0.40	0.12
522−025	1 49 06.5	35 53 00	15.6	0.90×0.60	Sbc	6	…	…	< 0.43	< 0.10	> 0.63	> 0.54
UGC 1330	1 49 11.4	34 47 30	16.0	1.30×1.30	S dm	9	4383	119	2.83	1.03	0.16	0.16
522−031	1 49 25.7	35 33 00	15.2	1.00×0.80	Sb	5	4099	…	< 0.41	< 0.07	> 0.73	> 0.72
503−043	1 49 38.0	31 44 23	15.6	1.30×1.20	Sbc	6	10757	256	2.15	0.50	0.28	0.26
522−035	1 49 38.1	36 15 22	14.0	1.70×0.80	SBa	3	4398	…	< 0.88	< 0.04	> 0.81	> 1.08
522−036	1 49 45.4	35 53 51	14.5	1.20×0.25	S0a	2	4526	…	< 0.67	< 0.05	> 0.38	> 0.40
522−038	1 49 49.7	36 22 30	13.9	1.40×1.20	Sc	7	5542	126	5.59	0.23	−0.15	−0.11
522−041	1 49 57.6	35 48 21	14.3	1.70×1.70	Sc	7	6105	236	2.34	0.14	0.41	0.45
522−042	1 50 00.7	36 16 07	14.5	2.10×1.50	SBb	5	5244	…	< 0.59	< 0.05	> 1.13	> 1.12
522−047	1 50 32.9	35 58 33	13.9	1.60×0.35	S0a	2	4470	…	< 0.91	< 0.04	> 0.49	> 0.53
522−049	1 50 53.7	36 19 07	15.3	1.00×0.60	Sd:	8	4684	208	1.33	0.21	0.35	0.27
522−050	1 50 56.2	36 20 27	15.7	1.20×0.40	Sc	7	5740	231	2.22	0.43	0.13	0.15
522−051	1 50 53.4	36 32 33	15.1	0.55×0.55	Sd	8	…	…	< 0.37	< 0.06	> 0.50	> 0.29
522−055	1 51 22.6	36 23 07	14.7	1.70×0.45	SBc	7	…	…	< 0.77	< 0.06	> 0.80	> 0.83
522−062	1 52 04.3	36 40 36	15.2	0.85×0.45	SBb	5	5621	197	2.13	0.29	−0.06	−0.08
522−063	1 52 13.9	36 01 00	15.4	1.10×0.90	Irr	9	4532	237	3.57	0.67	−0.10	−0.08
522−064	1 52 14.5	35 02 10	13.8	2.50×2.20	…S0?	1	5362	…	< 0.45	< 0.02	> 1.18	> 1.24
522−069	1 53 00.8	36 53 00	14.9	1.40×1.20	Sc:	7	5218	154	1.38	0.14	0.47	0.49
522−071	1 53 07.8	35 53 08	13.8	2.50×0.35	Sb	5	…	…	< 1.52	< 0.03	> 0.85	> 0.81
522−073	1 53 26.2	36 58 16	15.6	1.40×0.60	SBb	5	4458	276	3.54	0.64	0.13	0.12
522−074	1 53 23.4	37 12 40	15.7	1.20×0.12	Sc	7	…	…	< 1.48	< 0.22	> 0.20	> 0.21
522−078	1 53 42.3	33 56 00	13.9	1.80×0.80	Sb	5	4634	458	16.08	0.52	−0.29	−0.32
503−058	1 53 59.8	32 46 16	14.9	1.70×0.30	S…	5	4609	365	2.35	0.09	0.49	0.47
503−060	1 54 12.8	32 32 41	14.3	1.30×0.50	Pec	10	4583	348	3.93	0.24	0.37	0.17
522−086	1 54 45.4	35 40 21	12.6	3.30×2.10	Sc	7	4880	338	31.43	0.40	−0.14	−0.09
522−094	1 55 56.7	36 25 58	14.0	1.40×0.90	Sab	4	4845	285	1.40	0.06	0.50	0.80
UGC 1470	1 56 48.4	31 50 33	16.5	1.70×0.20	S dm	9	5166	256	3.73	2.06	0.27	0.25
UGC 1472	1 57 02.2	34 06 00	18.0	1.30×1.20	Dw sp	9	4849	149	4.00	8.80	0.02	0.00
522−100	1 57 12.5	37 21 37	15.0	1.60×1.20	S dm	9	4044	177	3.93	0.55	0.19	0.19
522−102	1 57 55.9	37 58 15	14.0	2.30×0.80	Sab	4	4105	283	1.61	0.05	0.86	1.16
503−073	1 58 12.3	31 38 27	12.8	1.70×1.40	Sc	7	5190	74	9.32	0.16	−0.20	−0.16
503−077	1 59 31.2	31 49 55	14.0	0.70×0.35	Pec	10	5267	254	3.24	0.15	0.01	−0.18
UGC 1535	2 00 12.8	36 04 27	17.0	1.10×0.90	Dw Irr	9	4320	76	3.72	3.19	−0.10	−0.10
522−105	2 00 27.9	37 52 41	13.1	1.90×1.40	Sa	3	5660	436	6.12	0.21	0.12	0.41
522−111	2 02 36.0	34 38 36	15.2	1.80×0.80	Irr	9	4411	360	15.03	2.32	−0.29	−0.30
522−116	2 05 42.7	38 32 22	12.7	3.50×1.40	Sbc	6	4245	466	16.65	0.21	0.26	0.24
504−018	2 06 14.6	31 45 27	14.7	1.50×1.50	S dm	9	5006	115	11.28	0.94	−0.33	−0.33
UGC 1650	2 06 26.1	37 01 20	17.0	2.20×0.10	Sc	7	4585	250	5.94	2.56	0.25	0.26
522−131	2 08 16.9	37 15 48	12.8	2.00×1.00	SBa/Sb	4	4543	420	7.01	0.10	0.12	0.40
504−026	2 08 39.1	31 16 33	14.7	1.20×0.50	Sc	7	4983	247	3.64	0.26	−0.09	−0.07
UGC 1712	2 10 50.5	33 22 06	17.0	1.00×1.00	S dm	9	5090	136	3.33	2.73	−0.14	−0.14

TABLE 1 — *Continued*

Source (1)	R.A. (2)	Decl. (3)	*m* (4)	Size (5)	Type (6)	Code[a] (7)	$V_\odot$ (km s^{-1}) (8)	Width (km s^{-1}) (9)	$\int S\,dv$ (Jy km s^{-1}) (10)	$\frac{M_H/L}{M_\odot/L_\odot}$ (11)	*Def* (12)	*Def'* (13)
522−140	2 11 32.6	37 10 33	14.5	2.30×2.30	SBc	7	4638	136	13.47	1.02	−0.08	−0.05
504−036	2 11 54.5	31 14 13	14.6	1.90×0.40	Sbc	6	5275	362	10.16	0.39	−0.05	−0.10
504−038	2 12 07.3	32 29 30	15.6	1.70×1.00	Sc	7	4443	195	6.81	1.32	−0.04	−0.03
523−005	2 13 50.8	35 41 00	14.8	1.50×0.60	Sb	5	8199	521	3.98	0.27	0.15	0.12
504−041	2 13 15.6	32 25 08	14.5	2.30×1.20	Sbc	6	4819	471	6.87	0.06	0.27	0.24
504−043	2 13 26.9	31 46 06	14.6	1.40×0.40	Sab	4	8751	423	6.41	0.25	−0.15	0.12
504−049	2 14 54.0	32 10 00	14.8	2.70×0.40	Sa	3	4794	454	3.94	0.12	0.58	0.90
UGC 1771	2 15 16.3	37 39 46	17.0	2.20×1.80	Dw sp	9	4332	68	4.02	3.51	0.48	0.44
504−053	2 15 53.4	33 29 30	15.6	1.40×1.10	S dm	9	5032	200	4.37	0.96	0.03	0.02
523−022	2 16 35.5	37 42 23	14.7	1.40×0.50	Irr	9	6421	421	7.32	0.65	−0.21	−0.21
504−062	2 18 34.4	32 19 03	14.8	1.80×0.80	Sab	4	5312	563	4.36	0.30	0.21	0.51
504−063	2 18 48.0	32 47 27	15.1	1.80×0.35	Sc	7	3960	262	7.00	0.55	−0.02	0.00

NOTES.—522−020, 522−038, 522−086, 503−073, and 503−077 observed by Bania, Thompson, and Thuan. 522−105 also observed by S. Peterson at the NRAO 92 m telescope. His flux is twice as large as ours.

[a] The code listed in col. (7) identifies the morphological type of the galaxy for the purpose of applying the recursion relation coefficients listed in Table 2.

TABLE 2

COEFFICIENTS OF THE RECURSION RELATIONS FOR $[\log(M_H/L)]_{cs,i}$ and $[\log(M_H/D^2)]_{cs,i}$

Type	Code	a_i	b_i	c_i	d_i
S0	1	−7.58	0.466	6.31	0.25
S0a	2	−7.58	0.466	6.31	0.25
Sa	3	−5.13	0.313	7.22	−0.09
Sab	4	−6.19	0.384	7.22	−0.09
Sb	5	−6.17	0.386	6.89	−0.05
Sbc	6	−6.09	0.381	6.65	0.10
Sc	7	−6.61	0.410	6.65	0.10
Scd, Sd	8	−4.70	0.293	6.95	−0.10
Irr, DwSp, S dm ...	9	−6.56	0.410	6.95	−0.10
Pec	10	−5.25	0.346	7.60	−0.49

Table 1, the data used were not obtained by us, as previous observations made by T. Bania, L. Thompson, and T. Thuan were kindly made available prior to publication. Source names refer to the *Catalogue of Galaxies and Clusters of Galaxies* (Zwicky *et al.* 1960–1968; hereafter CGCG); galaxies fainter than 15.7 are listed by their entry number in the *Uppsala General Catalogue* (Nilson 1973; hereafter UGC); magnitudes are either obtained from the CGCG or the UGC; sizes are either those of the UGC or measured directly on the Palomar Sky Survey (PSS) prints. Morphological types are either Nilson's or derived from inspection of both the PSS and plates obtained by B. Marano and G. Vettolani at the 1.5 m telescope of the University of Bologna (scale 17″mm^{-1}) which cover approximately 2°×2° around A262.

Column (8) of Table 1 lists the heliocentric velocity of each galaxy, as derived from 21 cm observations (if detected) or available optical data. For the latter we are indebted to Dr. H. Rood who made available to us his private compilation of published and unpublished redshifts. In column (9) we list the measured velocity width of the H I profile. Both velocity and velocity width correspond to the average values measured using two different criteria. In the first, the width is measured at a level equal to 50% of the flux over the signal; in the second, it is measured at a level equal to 20% of the peak flux over the signal. The velocity is correspondingly taken as the value midpoint between the extremes of the velocity width interval. These two criteria proved to be the ones which yield the smallest dispersion around the average values of widths and velocities measured for a sample of several hundred galaxies (Haynes and Giovanelli 1982) according to five different criteria currently used by 21 cm observers. The velocity widths of the five galaxies observed by Bania, Thompson, and Thuan included in Table 1 have been corrected to consistency with our method. None of the widths listed in Table 1 have been corrected by the $(1+z)^{-1}$ relativistic factor, which at the redshift of A262 amounts to only about 1.7%. Column (10) gives the integrated flux in Jy km s^{-1}, corrected to take into account the response of the telescope's beam to an extended source. The quantities relevant to the analysis presented in this paper, i.e. luminosities, diameters, and H I masses of the sample galaxies, were derived following conventions that are fully described by Chincarini, Giovanelli, and Haynes (1982). The distance independent ratio M_H/L is given in column (11) of Table 1.

III. ANALYSIS

a) The Deficiency Pattern

The H I deficiency of a galaxy is customarily defined as

$$Def = [\log(M_H/L)]_{cs} - \log(M_H/L), \qquad (1)$$

where M_H is the H I mass, L is the photographic luminosity, and the ratio M_H/L is a distance independent quantity; the subscript "cs" indicates that the value in square brackets is to be derived from a comparison sample. Our comparison sample consists of 270 detected isolated galaxies, observed by Haynes and Giovanelli (1982) at Arecibo. The isolated galaxies, chosen from a list by Karachentseva (1973), represent a population as little encumbered as possible by environmental constraints on their evolution. Early determinations of *Def* were made by using one value of $[\log(M_H/L)]_{cs}$ for all galaxies of a given morphological type. Preliminary data of the isolated galaxy sample showed that within a morphological type, a residual dependence of M_H/L on L is detectable (Giovanelli, Chincarini, and Haynes 1981). Successive analysis on the whole sample showed that M_H/L correlates better with surface brightness, or any quantity involving the diameter of the galaxy. Surface brightness is a distance independent quantity and was opportunely chosen as the M_H/L indicator. Details on the statistical and physical justification of this choice will be presented with the isolated galaxy data. Expressions of $[\log(M_H/L)]_{cs}$ were obtained as functions of surface brightness, for each morphological type, in the form

$$[\log(M_H/L)]_{cs,i} = a_i + b_i\,\mathrm{SB}, \qquad (2)$$

where i identifies the morphological type and SB the surface brightness expressed as $m + 5\log a$, where m is the apparent magnitude corrected for internal and galactic extinction, biases in the Zwicky catalog as discussed by Kron and Shane (1976) and after application of the K-correction, and a is the major angular diameter as listed in column (5) of Table 1. Table 2 lists the coefficients of the recursion relations (2), as used to compute *Def* according to (1). Values of *Def* are given for each galaxy in column (12) of Table 1.

The quality of the apparent magnitudes listed in the CGCG, and used as part of the optical data base throughout this paper, has recently been criticized with renewed vigor (Auman, Hickson, and Fahlman 1982; Bothun and Schommer 1982), and doubts have been cast on the reliability of the values of M_H/L obtained using CGCG magnitudes, with an impact of *Def* as derived by equation (1). One may circumvent this problem if one can use a hydrogen content indicator that is independent on CGCG magnitudes. The distance independent ratio M_H/D, where D is the galaxy's linear major optical blue diameter, allows such an approach. Inferring D from the angular diameters given in the UGC, we analyzed the relation $M_H \propto D^n$ for the same set of isolated galaxies described above. The exponent n is close to 1.8 for all morphological types. Assuming then that $M_H D^{-2}$ can be parametrized by a weak power law dependence on D, we derived recursion coefficients for the relation

$$[\log(M_H/D^2)]_{cs,i} = c_i + d_i \log(D) \qquad (3)$$

(where the subscripts have the same meaning as in eq. [1]) which we also list in Table 2. Since the relation between M_H and D is so close to one of the type $M_H \propto D^2$, uncertainties in the value of the Hubble constant have a negligible effect on the value of c_i and d_i. We then may define an alternative deficiency parameter

$$Def' = [\log(M_H/D^2)]_{cs} - \log(M_H/D^2) \qquad (4)$$

for each cluster galaxy. We list the computed values in column (13) of Table 1. The agreement between the two methods of determining deficiency is very good, as shown in Figure 1. The objects that show the large disagreements in the sense that $Def' > Def$, tend to be relatively large angular diameter galaxies. There are some indications that some of those may have H I sizes substantially larger than the Arecibo telescope's beam, and therefore our corrected fluxes may indeed be in error by defect. For example, 522−105 was also observed by Peterson (1979) with the 300 foot telescope at Green Bank, which has a beamwidth 3 times larger than the Arecibo dish; he obtained an integrated H I flux twice as large as the corrected one listed by us; if the difference is not due to observational errors, one would infer an unusually large H I diameter for that galaxy, with at least half of its flux missed by the 3'.3 Arecibo beam.

The comparison between the two methods of determining the H I deficiency is reassuring, as the biases involved in obtaining the two different optical data bases are presumably uncorrelated. A wider discussion of this subject will be presented elsewhere. For an easier comparison with other studies, in what follows we shall use only the deficiency parameter as defined by equation (1), satisfied that the conclusions drawn are corroborated by the alternative use of equation (4).

1982ApJ...262..442G

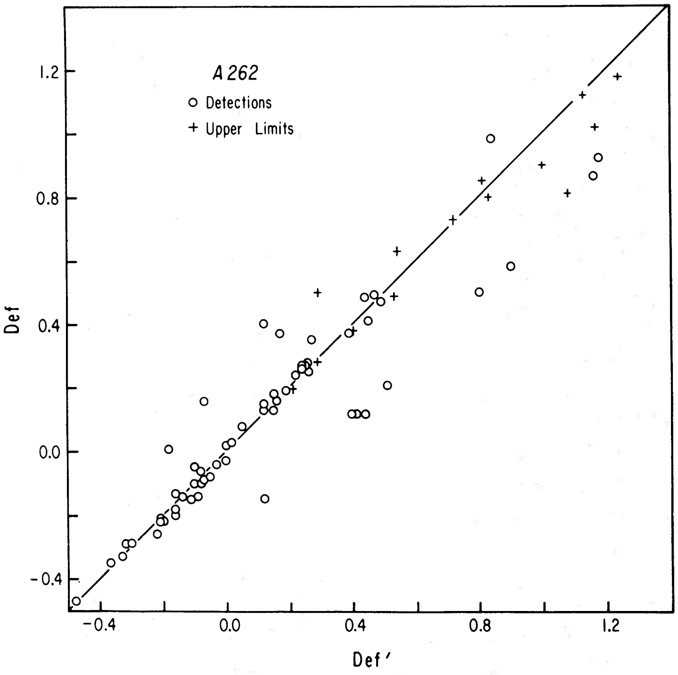

FIG. 1.—Comparison between the independent determination of the H I deficiency parameter *Def* (obtained using M_H/L as an H I content indicator) and *Def'* (obtained using M_H/D^2). The straight line has slope 1. The circles identify detected galaxies, while the crosses refer to the undetected ones.

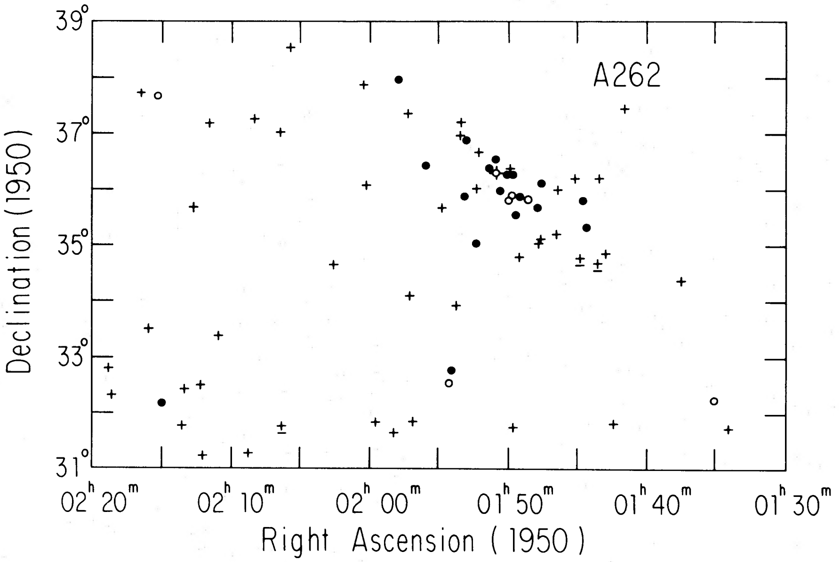

FIG. 2.—Each symbol represents a galaxy listed in Table 1. Galaxies that are deficient in M_H/L by at least a factor of 3 are identified by filled circles, and those deficient by at least a factor of 2 by open circles. Galaxies that have M_H/L twice or more times the amount of those in the comparison sample are identified by underscores.

In Figure 2, all the galaxies listed in Table 1 are identified by one of four possible symbols, depending on the derived value of *Def*. Galaxies deficient in H I by at least a factor of 2 with respect to the comparison sample are identified by circles, which are filled if the deficiency factor is larger than 3. Crosses identify galaxies not found deficient; they are underscored if the galaxies appear H I-rich by at least a factor of 2.

One note of reservation must be made in the interpretation of *Def* for early type galaxies. Regressions

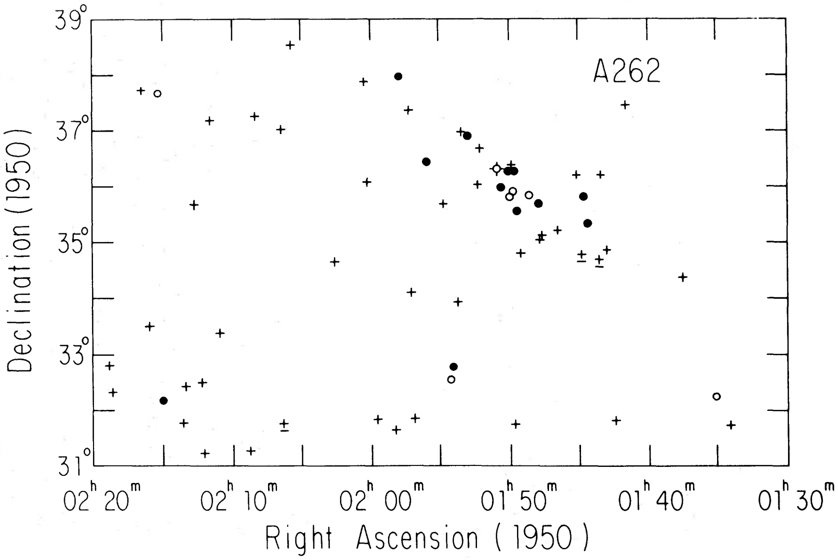

FIG. 3.—Same as Fig. 1, except that six galaxies of unknown redshift (522−012, 522−025, 522−051, 522−055, 522−071, and 522−074) and two of early morphological type (522−017 and 522−064) have not been plotted.

for [log $(M_H/L)]_{cs}$ versus surface brightness were computed using only detected galaxies in the isolated sample; while the detection rate is very high for later morphological types, types earlier than S0/*a* show a distinct dichotomy. Their H I content is either comparable with later type systems of comparable size and luminosity (Haynes and Giovanelli 1980; Hawarden *et al.* 1981), or it is extremely low. Hence, the use of detected galaxies only as a reference system will yield deficiencies that for early type galaxies, such as 522−017 and 522−064, may not be truly (or fully) representative of the effects due to the cluster environment.

The redshifts of galaxies 522−012, 522−025, 522−051, 522−071, and 522−074 are not known. Their deficiencies were computed in the assumption that they lie within the range of observed velocities, which for galaxies in the central parts of A262 is 3300-6900 km s^{-1}.

In Figure 3 we have plotted only those galaxies unaffected by the uncertainties mentioned above. The pattern of concentration of H I deficient galaxies toward the center of the cluster still clearly emerges. In Figure 3, more than 80% of the galaxies within the central square degree of the cluster are deficient (9 out of 11), while only 15% show any deficiency in the rest of the field.

Substantial H I deficiency has been detected also in the Hercules (Giovanelli, Chincarini, and Haynes 1981), Coma (Sullivan *et al.* 1981; Chincarini, Giovanelli, and Haynes 1982), and Virgo (Chamaraux, Balkowski, and Gerard 1980; Giovanardi *et al.* 1982) clusters. H I deficiency appears to be associated with cluster X-ray emission. In fact, in the Hercules supercluster, H I deficiency is observed to be quite significant in A2147, an X-ray cluster, while it appears to be only marginal at best in A2151, a cluster of richness and velocity dispersion comparable with A2147, but inconspicuous in its X-ray emission. The results presented here for A262 confirm this pattern, suggesting that a mechanism related to the presence of an intracluster medium is responsible for the removal of the H I gas from cluster galaxies.

b) *Cluster Parameters*

Moss and Dickens (1977) and Gregory, Thompson, and Tifft (1981) have obtained cluster properties for A262 on the basis of their optical data. Because of the increased amount and improved quality of the redshifts available to us, we have obtained a new set of dynamical parameters for the clusters, which are given in Table 3. Following the procedure outlined by Materne (1974), we list the velocity for the center of mass of the system, V_{cm} (measured with respect to the Local Group), the dimensionless crossing time, Ht_c (where H is the Hubble constant), virial radius R_{vir} and velocity dispersion V_{vir}, and the virial mass M_{vir}. These parameters are estimated separately for spiral galaxies, for *E* and S0's and for the total sample. In addition to the galaxies listed in Table 1, we have used those not included there for which a redshift was published by Moss and Dickens (1977) or Gregory, Thompson, and Tifft (1981); the total number of galaxies used for each subsample is listed in column (7) of Table 3. The parameters were computed weighting by mass by arbitrarily assuming a mass-to-luminosity ratio of 10 for E and S0 galaxies and of 5 for spirals; however, the results vary little if obtained weighting by luminosity. The question of cluster membership is a difficult one to solve unambiguously. The cluster is elongated roughly along the same direction as a super-

TABLE 3

DYNAMICAL PARAMETERS OF A262

Sample (1)	V_{cm} (km s^{-1}) (2)	Ht_c (3)	R_{vir} (Mpc) (4)	V_{vir} (km s^{-1}) (5)	M_{vir} ($10^{14} M_\odot$) (6)	N (7)
All	5068	0.13	5.1	783	7.25	53
E/S0	4964	0.23	4.3	510	2.6	17
S...........	5174	0.12	6.3	952	13.2	36

NOTE.— $H_0 = 50$ km s^{-1} Mpc^{-1} assumed.

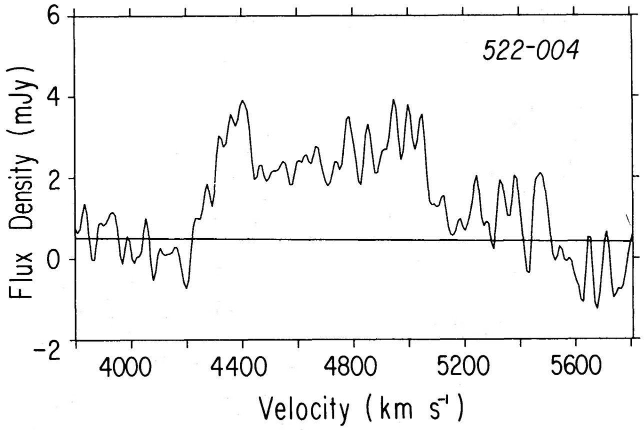

FIG. 4.—"Raw" H I profile of galaxy 522–004. The smooth curve represents the linear baseline fit to the profile.

cluster filament which extends over about one radian, and the average velocity and the velocity dispersion within the cluster does not seem to differ substantially from the one observed in nearby lower density regions of the supercluster. A parameter which was found to depend little on the assumed extent of the cluster is the dynamic mass-to-luminosity ratio. For the area enclosed between $01^h40^m <$ R.A. $< 02^h01^m$ and $34° <$ decl. $< 38°$, the luminosity of all galaxies brighter than 15.0 mag is $3.0 \times 10^{12} L_\odot$; the application of a Schechter luminosity function yields a total luminosity of $8.2 \times 10^{12} L_\odot$, for a ratio M_{vir}/L_{tot} of 89. For these calculations, a value of 50 km s^{-1} Mpc^{-1} was assumed for the Hubble constant.

c) *The Galaxy 522–004*

Before passing to discuss the implication of the observed pattern of H I deficiency of A262, we wish to briefly mention the galaxy 522–004, also known as UGC 1248 or NGC 669. It is one of the galaxies with the largest optical linear diameter in the field, about 50 h^{-1} kpc (where the Hubble constant is 100 h km s^{-1} Mpc^{-1}), and one of the brightest. Although detected, it is strongly deficient in its H I content, a peculiar instance given its distance from the cluster core and its relative isolation. However, its most distinguishing characteristic is the enormous width of its H I profile, shown in Figure 4. The measured width is 873 km s^{-1}, fairly reliably determined in spite of the weakness of the signal, confirmed in observations obtained in three different epochs. The baseline fit to the profile is linear. The total mass, inferred by assuming the customary Brandt formula with index corresponding to a flat rotation curve, is $1.1 \times 10^{12} h\, M_\odot$.

IV. DISCUSSION

The velocity dispersion of the ensemble of all galaxies in A262 is relatively low, especially when compared with those of H I deficient clusters such as A2147 and Coma. As the ram pressure exercised upon the interstellar gas of a galaxy travelling through the intracluster medium (ICM) is proportional to the square of the velocity and the density of the ICM, one infers that the density of the ICM in A262 is rather high, if ram pressure stripping is invoked to explain the observed H I deficiency in cluster galaxies. As the X-ray data do not provide an unambiguous indication of the density of the ICM, there is no immediate corroboration of such an inference. Other mechanisms may be invoked for removal of the H I gas in cluster galaxies. While galaxy-galaxy collisions may not appear the most attractive (Giovanelli, Chincarini, and Haynes 1981), thermal evaporation in the form described by Cowie and Songaila (1977) provides an interesting alternative, especially in low velocity dispersion clusters.

The observation of H I deficiency in cluster galaxies appears to be connected with the presence of X-ray emission, and the inferred existence of a relatively hot and dense ICM, as in the case of Coma, A2147, and A262. While the low velocity dispersion cluster A262, with a centrally located X-ray source, shows prominent signs of H I deficiency, the higher velocity dispersion, poor X-ray emitter A2151 does not. Why does a cluster like A262 develop the ability to strip its galaxies of their gas while one richer and more massive like A2151 apparently does not? According to most views on cluster evolution (e.g., Gisler 1979; Sarazin 1979), the efficiency of processes leading to sweeping of the gaseous contents of galaxies matures rather suddenly at a relatively late stage. The case of A2151, with its lack of a diffuse X-ray source and of a dominating, centrally located elliptical galaxy, seems to point toward a condition of arrested development. However, it should be pointed out that the H I data base for that cluster is still relatively fragmentary and should be improved.

Even more striking than the contrast between A262 and A2151 is the fact that in those clusters where H I deficient galaxies are found, they are found in such abundance. The largest fraction of spiral galaxies in the central parts of clusters such as A262 are deficient. Since sweeping events, once they become effective, are thought to occur over short time scales, the large number of H I deficient galaxies observed in several nearby clusters poses the choice between the following alternatives: either our epoch is extremely singular in allowing us to witness such wealth of short-lived sweeping phases in nearby clusters or the deficiency of H I does not imply the final loss of the galaxy's interstellar medium. The alternative that the mass of interstellar material, if swept out of the galaxy in the course of a transit through the cluster core, may be replenished by stellar mass loss in one crossing time is highly unlikely, as the required mass loss rates would exceed by about one order of magnitude the higher values allowed by stellar evolution considerations.

Excluding the idea that we live in a peculiar epoch, how can we account for so many spirals without H I? Quite an analogous question was posed by Bechtold *et al.* (1981) upon their discovery of X-ray coronae around galaxies in the cluster A1367. The number of such coronae, which could conceivably be stripped as easily or more so as the H I disks of galaxies, was found to be puzzlingly large. Unless the stellar mass loss rate in those galaxies is unpalatably high, as convincingly argued by Bechtold *et al.*, the gas must be prevented from streaming out into the ICM, under the influence of ram pressure or evaporative process. That may be possible if the galaxies possess massive dark haloes, which to a large extent bind their gaseous content. We may speculate that the interstellar medium, upon crossing of the cluster core, may be heated by conduction or other processes, becoming invisible in the 21 cm line and temporarily being converted into a hot X-ray emitting corona. Cooling and return of the gas to the disk may occur over the period the galaxy spends far from the cluster core. Whether this qualitative picture may withstand the trial of computations remains a desirable task to pursue. Computational verification of this speculation may help explain the observed situation of the apparently disproportionately large numbers of spiral galaxies in clusters.

We would like to thank Dr. T. M. Bania for kindly providing us with the results of his observations with Drs. L. Thompson and T. Thuan prior to publication, Dr. W. Forman for the communications regarding the X-ray source in A262, and Drs. B. Marano and G. Vettolani for allowing inspection of their 1.5 m telescope plates.

REFERENCES

Auman, J. R., Hickson, P., and Fahlman, G. G. 1982, *Pub. A.S.P.*, **94**, 19.
Bechtold, J., Forman, W., Giacconi, R., Jones, C., Schwarz, J., Tucker, W., and van Speybroeck, L. 1981, preprint.
Bothun, G. D., and Schommer, R. A. 1982, *Ap. J. Letters*, **255**, L23.
Chamaraux, P., Balkowski, C., and Gerard, E. 1980, *Astr. Ap.*, **83**, 38.
Chincarini, G. L., Giovanelli, R., and Haynes, M. P. 1982, preprint.
Cowie, L. L., and Songaila, A. 1977, *Nature*, **266**, 501.
Fanti, C., *et al.* 1981, preprint.
Forman, W. R. 1981, personal communication.
Giovanardi, C., Salpeter, E. E., Helou, G., and Krumm, N. 1982, preprint.
Giovanelli, R., Chincarini, G. L., and Haynes, M. P. 1981, *Ap. J.*, **247**, 383.
Gisler, G. R. 1979, *Ap. J.*, **228**, 385.
Gregory, S. A., Thompson, L. A., and Tifft, W. G. 1981, *Ap. J.*, **243**, 411.
Hawarden, T. G., Longmore, A. J., Goss, W. M., Mebold, U., and Tritton, S. B. 1981, *M.N.R.A.S.*, **196**, 1975.
Haynes, M. P., and Giovanelli, R. 1980, *Ap. J. Letters*, **240**, L87.
______. 1982, in preparation.
Kalloglyan, A. T. 1972, *Astrofizika* **5**, 43.
Karachentseva, V. E. 1973, *Comm. Spec. Ap. Obs.*, **8**.
Kron, G. E., and Shane, C. D. 1976, *Ap. Space Sci.*, **39**, 401.
Materne, J. 1974, *Astr. Ap.*, **33**, 451.
Melnick, J., and Sargent, W. L. W. 1977, *Ap. J.*, **215**, 401.
Moss, C. and Dickens, R. J. 1977, *M.N.R.A.S.*, **178**, 701.
Nilson, P. 1973, *Uppsala General Catalogue of Galaxies*, *Uppsala Astr. Obs. Ann.*, **6** (UGC).
Peterson, S. D. 1979, *Ap. J. Suppl.*, **40**, 527.

Sarazin, C. L. 1979, *Ap. Letters*, **20**, 93.
Sullivan, W. T., III, Bothun, G. D., Bates, B., and Schommer, R. A. 1981, *A.J.*, **86**, 919.
Zwicky, F., and Kowal, C. T. 1968, *Catalogue of Galaxies and Clusters of Galaxies*, Vol. **6** (Pasadena: California Institute of Technology). (CGCG).

GUIDO L. CHINCARINI: Department of Physics and Astronomy, University of Oklahoma, Norman, OK 73069

RICCARDO GIOVANELLI: Arecibo Observatory, P.O. Box 995, Arecibo, PR 00613

MARTHA P. HAYNES: National Radio Astronomy Observatory, P.O. Box 2, Green Bank, WV 24944