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GASEOUS CONTENT OF GALAXIES INSIDE GROUPS

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RESUMEN

Hemos analizado el contenido gaseoso de un ejemplo constituido de galaxias 84 Sb y 95 Sc dentro de grupos. Después de corregir por el efecto de luminosidad (significativo en el caso de las Sc) no se encontró deficiencia de gas para esas galaxias, a pesar de una diferencia de cerca de 2 órdenes de magnitud en la densidad galáctica. Cualquier gas intergaláctico presente en los grupos considerables debe de tener densidades menores que 3×10^{-4} cm^{-3}.

ABSTRACT

We have analysed the gaseous content of a sample constituted of 84 Sb and 95 Sc galaxies inside groups. After correcting for the luminosity effect (significant in the case of Sc's) no gas deficiency was found for those galaxies in spite of a span of about 2 orders of magnitude in the galaxian density. Any intergalactic gas present in the considered groups must have densities smaller than 3×10^{-4} cm^{-3}.

Key words: **CLUSTERS - GALAXIES – GALAXIES - SPIRAL**

I. INTRODUCTION

Several observational studies seem to indicate that spiral galaxies located in the core of a dense cluster have a deficiency in their hydrogen content in comparison with field objects of the same morphological type. Davies and Lewis (1973) found a slight deficiency in a sample of 25 spirals and irregulars in the Virgo cluster. This result was contested by Bottinelli and Gouguenheim (1974), who argued that the deficiency found by Davies and Lewis was, in fact, due to the high luminosity of the objects present in their sample. However, Huchtmeier, Tammann and Wendker (1976) correcting for the luminosity effect in a sample of 39 objects, confirmed the findings by Davies and Lewis. Later Chamaraux, Balkowski and Gérard (1980) studied a larger sample including 56 spiral galaxies in Virgo, showing that the hydrogen deficiency is related with the "anaemic" characteristics of the objects. For disk-galaxies located in the core of Virgo, Giovanardi *et al.* (1983) have shown that both normal and "anaemic" galaxies have, on the average, a smaller mass of gas in comparison with galaxies of same type localized in the outer parts of the cluster. These last studies suggest that the ram-pressure induced by an intra-cluster gas is responsible for the observed deficiency in the gaseous content.

The possible effect of the ram-pressure on the gas content of galaxies was also studied by Giovanelli and Haynes (1985). These authors compared the hydrogen content of spirals in nine clusters with a sample of isolated objects, having the same morphological type and comparable linear diameters. They concluded that the deficiency presented by galaxies in some clusters is correlated with the radial distance to the centre and the presence of X-ray emission. These results support the idea that the hot intra-cluster gas could be responsible for the observed variations in the gas content of spirals located in different regions with respect to the cluster centre.

Groups of galaxies have, in general, a considerable high galaxian density in comparison with the background, but no hot gas was detected until now in those objects. Therefore, the analysis of the gaseous content of galaxies in groups may represent an additional contribution to studies about the effects of the environment in the evolution of those objects. The studies already performed do not show a clear picture of the situation. Balkowski and Chamaraux (1981) concluded that 22 galaxies members of de Vaucouleurs groups (de Vaucouleurs 1975) have an hydrogen content larger than that of 8 isolated similar objects. However, some of the isolated galaxies considered by those authors are actually listed as members of groups by Geller and Huchra (1983). Moreover, Krumm and Shane (1982) analysed the gas distribution in NGC 2712 and NGC 5301, both galaxies included in the sample by Balkowski and Chamaraux, concluding that such a distribution is similar to those of galaxies with companions. The gaseous content of 230 galaxies (spirals and irregulars) members of groups listed by Geller and Huchra (1983) were extensively studied by Giuricin, Mardirossian and Mezzetti (1985).

They have shown that the hydrogen content does not depend on the galaxian distance to the centre or either on the ratio between that distance to the average separation between pairs. However, they have defined a deficiency factor based on an average including different morphological types. Since galaxies with different Hubble types have a different gaseous content, a global average may mask possible environment effects.

In the present paper we report an analysis of the gaseous content of spiral galaxies members of well defined groups. We have considered only Sc and Sb objects and included a correlation for the luminosity effect. In spite of a span of about 2 orders of magnitude in the galaxian density, no environment effects were detected in the hydrogen content in members of the considered groups, confirming the conclusions by Giuricin *et al.* (1985) .

II. THE SAMPLE

Catalogues of groups prepared on the basis of visual inspection or by computer, using some criteria based on projected density contrast, may always be critized. In fact, besides the angular separation of galaxies, groups must be selected taking into account all available information such as radial velocity and magnitude of possible members.

In the present work we have prepared a culled sample based on the catalogue by de Souza (1983), where different criteria to assign membership were taken into account. The catalogue includes 115 groups. The groups G28, G58, G70, G90, G98 and G99 were not included in our analysis since they were considered uncertain by the author. All Sc and Sb galaxies members of those groups satisfying $m \leqslant 14.5$ were taken into account in our study. Magnitudes already corrected for reddening were taken from RC2 (de Vaucouleurs, de Vaucouleurs and Corwin 1976) when available. In the cases when such data were not existent, we used a calibration magnitude - angular diameter for different morphological types (Junqueira 1986) to obtain apparent magnitudes, following by reddening corrections. The magnitudes estimated by such a procedure may have errors as large as 0.5 mag. In our binning procedure, as we shall see later, we have distributed the galaxies inside luminosity bins of $\Delta\log L_B = 0.25$, which ensure us that in spite of possible calibration errors they are placed in the correct interval. The hydrogen masses were obtained from 21-cm measurements by Fisher and Tully (1981) or by Bottinelli, Gouguenheim and Paturel (1982). All radial velocities given by de Souza (1983) were revised. The adopted values were taken from Sandage and Tammann (1981), Huchra *et al.* (1983) and from the *Radial Velocities Catalogue of Galaxies* (Palumbo, Tanzella-Nitti and Vettolani 1983). The heliocentric values were corrected with respect to the centre of mass of the Local Group following the recipe given in the *Second General Catalogue of Bright Galaxies* (RC2). Since the galaxies NGC 5406, NGC 5515 and NGC 5541 have quite discrepant redshifts in the group G85, they have been discarded. For the same reason we have not included NGC 3274 in G37, NGC 4569 in G63 and NGC 2959 in G30. Under these conditions within the 109 groups considered in the present study, we have 84 Sb and 95 Sc galaxies which constitute our sample. Tables 1 and 2 give the actual data for Sb's and Sc's respectively on which our analysis was based. Column 1 indicates the NGC number, columns 2 and 3 give the logarithm of the neutral hydrogen mass (in solar units) and the logarithm of the B-luminosity (in solar units). Column 4 gives the 'corrected' $\log M_{H\,I}/L_B$ ratio following a recipe to be described in the next section. Columns 5 and 6 give the logarithm of the galaxian density inside the group (in Mpc^{-3}) and the radial velocity (in km s^{-1}) of the group, respectively. Finally columns 7 and 8 give the group number by de Souza and other identifications found in the literature.

III. THE METHOD OF ANALYSIS

First of all, for each group, using the coordinates of the members, we calculated the coordinates of the centre. These calculations were performed weighting the galaxian coordinates by the respective luminosity and by simple means. No significant differences were found between both procedures.

The galaxian density of the groups was estimated supposing that those objects form homogeneous structures. This assumption can be more or less justified if the crossing time is smaller than the Hubble time (Jackson 1975). In this case we would expect that the hydrogen content would be related to the average galaxian density of the group rather than the local density as can be observed in the dense clusters (de Souza *et al.* 1982). If, besides homogeneity, we suppose spherical symmetry, the density is given by (de Souza 1983)

$$D = 81\pi^2 \cdot N/4^7 \langle r_p \rangle^3 \quad , \qquad (1)$$

where N is the total number of galaxies in each group and $\langle r_p \rangle$ is the average projected distance of members to the centre. In fact, substructures have been found in some clusters of galaxies and, in particular, in Coma (Fichtett and Webster 1987), whose core is usually considered to be virialized. However, our groups have a considerably lower galaxian density, which difficults the detection of the presence of eventual substructures. In this case. homogeneity and spherical symmetry can only be considered as a reasonable first approximation, allowing an objective estimate of the galaxian density through equation (1).

The gaseous content of the spiral galaxies was measured by the ratio between the neutral hydrogen mass and the luminosity in the B band. Clearly the neutral hydrogen mass is not the total amount of interstellar gas in a given galaxy, since molecular and ionized hydrogen may be also present in considerable amounts.

TABLE 1

Sb's DATA

NGC/IC	log M_H	log L_B	$log\left[\frac{M_{HI}}{L_B}\right]_{cor}$	log d	VG	Group	REM
N0134	10.40	10.92	−0.36	−0.76	1562	1	VV39;N134
N0289	10.45	10.49	−0.08	−0.76	1562	1	VV39;N134
N0150	9.88	10.45	−0.64	−0.76	1562	1	VV39;N134
N0470	9.75	10.49	−0.77	−0.20	2411	4	N488;VV40;HG52
N0891	9.84	10.59	−0.74	0.23	783	9	N1023;ST21;VV7;HG67
N0949	8.86	9.62	−1.15	0.23	783	9	N1023;ST21; VV7;HG67
N1055	9.97	10.34	−0.46	−1.05	1386	10	CETUS I;ST22; VV15;HG44+48
N1068	9.49	11.04	−1.30	−1.05	1386	10	CETUS I;ST22; VV15;HG44+48
N1255	9.81	10.49	−0.70	−0.63	1550	13	ERIDANUS;ST23;VV31; HG30+32
N1300	9.83	10.67	−0.80	−0.63	1550	13	ERIDANUS;ST23;VV31;HG30+32
N1325	9.62	10.30	−0.77	−0.63	1550	13	ERIDANUS;ST23; VV31; HG30+32
N1792	9.45	10.45	−1.05	0.17	756	19	HG16
N2223	10.11	10.83	−0.60	−1.43	1904	20	N2207; VV36;HG34
N2925	10.08	10.67	−0.54	0.14	1941	31	HG36
N3223	10.11	11.04	−0.70	−0.36	2759	38	ANTLIA;ST4;HG18
N3627	9.18	10.49	−1.30	−0.15	929	44	LEO; ST27;VV9;TG27;VV11;HG56
N3686	8.95	9.92	−1.22	−0.15	929	44	LEO; ST27;VV9;TG27;VV11;HG56
N3992	9.84	10.56	−0.72	−0.29	1133	48	URSA MAIOR I; VV34;HG60
N3953	9.56	10.49	−1.00	−0.29	1133	48	URSA MAIOR I; VV34;HG60
N3813	9.59	10.15	−0.70	−1.11	1092	49	URSA MAIOR I;VV17; HG60
N3936	9.52	10.49	−1.00	−0.48	1669	51	N3923;VV44;HG28+27
N3981	10.11	10.23	−0.24	0.25	1459	52	HG33
N4157	9.76	10.26	−0.62	−0.06	878	54	URSA MAIOR I(S);ST28;VV32
N4217	9.62	10.20	−0.74	−0.06	878	54	URSA MAIOR I(S);ST28;VV32
N3675	9.41	10.18	−0.92	−0.94	721	61	C Vn II;ST31;VV10;HG60
N4051	9.23	10.08	−1.05	−0.94	721	61	C Vn II; ST31;VV10;HG60
N4258	9.95	10.70	−0.68	0.03	354	65	C Vn I;ST29;VV3;HG60 (?)
N5055	9.91	10.49	−0.62	−0.31	489	82	M101;VV5;TG82;ST33;HG75
N5290	9.75	10.75	−0.92	−0.28	2658	85	TG77;HG69
N5713	10.11	10.45	−0.40	−0.61	1656	93	VIRGO III; VV29;TG87;HG49
N5879	9.36	9.95	−0.85	0.74	881	96	N5866;VV30;HG78
N6925	10.41	10.96	−0.38	−0.68	2968	108	HG23
N7412	9.76	10.40	−0.68	−0.48	1504	115	GRUS;ST19;VV27; HG12+15
N7496	9.56	10.49	−0.96	−0.48	1504	115	GRUS;ST19;VV27; HG12+15
N7531	10.15	10.36	−0.29	−0.48	1504	115	GRUS;ST19; VV27; HG12+15
N0488	10.00	11.08	−0.82	−0.20	2411	4	N488;VV40;HG52
N0779	9.93	10.68	−0.68	−1.36	1859	5	CETUS II;VV33;HG45
N0615	9.74	10.46	−0.77	−1.36	1859	5	CETUS II;VV33;HG45
N1417	10.30	10.95	−0.47	−1.12	4019	14	HG47
N1566	9.91	10.59	−0.66	−0.11	910	18	DORADO;N1566;ST3;VV16;HG3
N2207	10.18	10.93	−0.60	−1.43	1904	20	N2207;VV36;HG34
N2268	9.95	10.78	−0.72	0.27	2404	21	HG92

TABLE 1 (CONTINUED)

NGC/IC	log M_H	log L_B	$log\left[\frac{M_{HI}}{L_B}\right]_{cor}$	log d	VG	Group	REM
N2841	9.46	10.43	−1.00	−0.58	649	23	N2841;ST24;VV6;HGG71+74
N2633	9.87	10.45	−0.62	−0.22	2362	25	HG90
N2964	9.60	10.40	−0.85	−1.26	1600	29	N2964;VV42;HG64+66
N3003	10.11	10.45	−0.38	−1.26	1600	29	N2964;VV42; HG64+66
N3124	9.98	10.93	−0.80	−1.00	3345	34	HG37
N3162	9.43	10.04	−0.82	0.40	1188	36	VV47;TG21;HG57
N3177	8.77	9.70	−1.30	0.40	1188	36	VV47;TG21;HG57
N3254	9.63	10.20	−0.72	1.15	1302	37	VV54;HG62;N3245
N3147	10.08	11.15	−0.80	−0.92	2940	39	TG32;HG87
N3310	10.20	10.83	−0.52	−0.92	1883	42	URSA MAIOR I; VV28
N3351	9.36	10.51	−1.15	−0.15	929	44	LEO;ST27;VV9;TG27;VV11;HG56
N3963	10.11	10.86	−0.60	−0.17	3362	50	HG79
N4050	9.43	10.15	−0.89	−0.25	1459	52	HG33
N4041	9.76	10.34	−0.68	0.69	1390	53	HG82
N4321	10.04	10.26	−1.30	−0.93	1896	63	VIRGO I(S);VV18;TG57;HG41
N4501	9.93	11.26	−1.00	−0.93	1896	63	VIRGO I(S); VV18;TG57;HG41
N4380	8.15	9.86	−2.00	1.08	915	64	VIRGO I(S');VV25;TG57;HG41
N4303	9.98	10.86	−0.74	−0.39	1279	68	VIRGO X; VV26;TG57;HG41
N4536	9.88	10.65	−0.72	−0.39	1279	68	VIRGO X;VV26; TG57;HG41
N4902	10.26	10.79	−0.43	0.76	2511	74	HG42
N5005	8.76	10.60	−2.00	0.78	1054	75	TG67;HG68
N5364	9.68	10.51	−0.82	0.68	1181	84	HG55
N5371	10.20	11.04	−0.64	−0.28	2658	85	TG77;HG69
N5351	9.95	10.36	−0.49	−0.28	2658	85	TG77;HG69
N5313	9.59	10.26	−0.80	−0.38	2658	85	TG77;HG69
N5383	10.23	10.77	−0.46	−0.28	2658	85	TG77;HG69
N5350	10.04	10.69	−0.60	−0.28	2658	85	TG77;HG69
N5301	10.08	10.46	−0.43	−0.86	1912	86	HG72
I4351	10.36	11.11	−0.49	−1.01	2551	88	HG26
N5545	9.67	10.00	−0.59	−0.28	3448	91	TG86
N5678	9.97	10.60	−0.62	−0.85	2248	92	HG76
N5577	9.93	10.15	−0.40	−0.61	1655	93	VIRGO III; VV29;TG87;HG49
N5746	9.73	10.85	−0.96	−0.61	1655	93	VIRGO III;VV29; TG87;HG49
N5676	9.96	10.94	−0.80	−0.17	2399	94	N5676;VV37; TG91;HG73
N5633	9.56	10.41	−0.92	−0.17	2399	94	N5676; VV37;TG91;HG73
I1029	9.76	10.26	−0.62	−0.17	2399	94	N5676; VV37;TG91;HG73
N5840	9.52	10.52	−1.00	0.32	1633	95	N5846;VV50;TG95;HG50
N5806	9.26	10.36	−1.15	0.32	1633	95	N5846;VV50;TG95;HG50
N6217	10.11	10.60	−0.49	−1.28	1836	101	N6643;VV51;ST34
I5271	9.34	10.08	−0.92	−0.48	1504	33	GRUS; ST19;VV27;HG12+15
N3054	9.30	10.76	−1.40	−0.39	2264	33	HG29
N5134	9.04	10.41	−1.52	0.55	1608	78	HG35

TABLE 2

Sc's DATA

NGC/IC	log M_H	log L_B	$log\left[\frac{M_{HI}}{L_B}\right]_{cor}$	log d	VG	Group	REM
N0024	9.08	9.64	−0.80	−2.24	283	2	SCULPTOR;ST20;VV1;HG13
N1003	9.84	9.96	−0.24	0.23	783	9	N1023;ST21;VV7;HG67
N1058	9.40	9.62	−0.47	0.23	783	9	N1023;ST21;VV7;HG67
N1042	9.83	10.45	−0.57	−1.05	1386	10	CETUS I;ST22;VV15; HG44+48
N1035	9.18	9.97	−0.92	−1.05	1386	10	CETUS I;ST22;VV15; HG44+48
N1073	9.86	10.26	−0.42	−1.05	1386	10	CETUS I;ST22;VV15; HG44+48
N0991	9.49	10.15	−0.70	−1.05	1386	10	CETUS I;ST22;VV15;HG44+48
N1179	11.34	10.45	−0.43	−0.63	1550	13	ERIDANUS;ST23;VV31;HG30+32
N1292	9.49	9.99	−0.62	−0.63	1550	13	ERIDANUS;ST23;VV31;HG30+32
N1187	9.84	10.56	−0.66	−0.63	1550	13	ERIDANUS;ST23;VV31;HG30+32
N1232	10.34	10.89	−0.38	−0.63	1550	13	ERIDANUS;ST23;VV31;HG30+32
N1385	9.59	10.38	−0.74	−0.63	1550	13	ERIDANUS;ST23;VV31;HG30+32
N1448	9.95	10.52	−0.52	−0.42	831	15	VV21;HG8;N1433
N1493	9.28	9.88	−0.74	−0.42	831	15	VV21;HG8;N1433
N2280	10.40	10.81	−0.23	−1.43	1904	20	N2207;VV36;HG34
N2139	9.99	10.41	−0.41	−1.43	1904	20	N2207;VV36;HG34
N2276	10.04	10.81	−0.57	0.57	2404	21	HG92
N2541	9.56	9.49	−0.23	−0.58	649	23	N2841;ST24;VV6;HG71+74
N2997	10.04	10.45	−0.39	−1.80	1353	27	N2997;VV8;HG38
N2763	9.52	10.15	−0.70	−1.80	1353	27	N2997;VV8;HG38
N2770	9.91	10.67	−0.66	−1.26	1600	29	N2964;VV42;HG64+66
N2403	9.81	10.15	−0.38	0.91	225	30	M81;ST25;VV2;HG85+86
N2976	7.86	8.72	−1.40	0.91	225	30	M81;ST25;VV2;HG85+86
N3274	8.95	8.84	−0.41	1.15	1302	37	VV54;HG62;N3245
N3184	9.49	10.04	−0.64	−1.18	772	41	N3184;ST26;VV12
N3198	9.81	10.11	−0.40	−1.18	772	41	N3184;ST26;VV12
N3319	9.45	9.81	−0.52	−1.18	772	41	N3184;ST26;VV12
N3486	9.56	9.93	−0.51	−1.18	772	41	N3184;ST26;VV12
N3726	9.67	10.20	−0.59	−1.18	772	41	N3184;ST26;VV12
N3631	9.72	10.40	−0.43	−1.18	772	41	N3184;ST26;VV12
N3596	9.45	10.08	−0.72	−0.15	929	44	LEO;ST27;VV9;TG27; VV11;HG56
N3628	9.99	10.72	−0.60	−0.15	929	44	LEO;ST27;VV9;TG27; VV11;HG56
N3810	9.41	10.11	−0.74	−0.15	929	44	LEO;ST27;VV9;TG27; VV11;HG56
N3346	9.26	9.76	−0.72	−0.15	927	44	LEO;ST27;VV9;TG27; VV11;HG56
N3893	9.79	10.32	−0.54	−0.06	878	54	URSA MAIOR I(S); ST28;VV32
N4096	9.30	10.04	−0.82	−0.06	878	54	URSA MAIOR I(S); ST28;VV32
N4183	9.49	9.89	−0.54	1.28	861	55	TG51;HG60
N4116	9.70	9.88	−0.34	0.66	1176	56	HG51
N4123	9.75	10.11	−0.42	0.66	1176	56	HG51
N4545	10.08	10.56	−0.41	−1.20	2659	57	HG83
N4490	9.96	10.26	−0.31	−0.94	721	61	C Vn II;ST31;VV10;HG60
N4631	10.20	10.76	−0.42	−0.94	721	61	C Vn II;ST31;VV10;HG60

TABLE 2 (CONTINUED)

NGC/IC	log M_H	log L_B	$log\left[\frac{M_{HI}}{L_B}\right]_{cor}$	log d	VG	Group	REM
N4136	9.08	9.49	−0.72	0.03	354	65	C Vn I;ST29;VV3
N4244	9.32	9.75	−0.62	0.03	354	65	C Vn I;ST29;VV3
N4517	9.93	10.59	−0.59	−0.39	1279	68	VIRGO X;VV26;HG41
N4731	10.15	10.56	−0.33	−0.83	1242	72	VIRGO Y;VV20;HG41
N4487	9.30	10.00	−0.82	−1.43	894	73	VIRGO V;VV35;HG41
N4504	9.64	9.91	−0.40	−1.43	894	73	VIRGO V;VV35;HG41
N4899	9.99	10.59	−0.52	0.76	2511	74	HG42
N5033	10.00	10.49	−0.41	0.78	1054	75	TG67;HG68
N5112	9.56	9.95	−0.52	0.78	1054	75	TG67;HG68
N5085	10.04	10.45	−0.39	−0.23	1743	77	HG31
N5068	9.45	9.81	−0.55	−0.26	312	79	N5128;VV4;HG19;ST32
N5457	10.18	10.52	−0.28	−0.31	489	82	M101;VV5;TG82; ST33;HG75
N5194	9.64	10.62	−0.89	−0.31	489	82	M101;VV5;TG82; ST33;HG75
N5474	9.23	9.36	−0.46	−0.31	489	82	M101;VV5;TG82; ST33;HG75
N5300	9.15	9.83	−0.82	0.68	1181	84	HG55
N5297	10.34	10.99	−0.43	−0.28	2658	85	TG77;HG69
N5320	10.08	10.52	−0.39	−0.28	2658	85	TG77;HG69
N5468	10.20	10.72	−0.37	−0.04	2524	89	HG46
N5584	9.76	10.28	−0.52	−0.61	1655	93	VIRGO III;VV29;TG87; HG49
N5907	10.11	10.56	−0.36	0.74	881	96	N5866;VV30;HG78
N7418	9.64	10.23	−0.60	−0.48	1504	115	GRUS;ST19;VV27; HG12+15
N7424	10.18	10.28	−0.11	−0.48	1504	115	GRUS;ST19;VV27; HG12+15
N7462	9.40	10.04	−0.74	−0.48	1504	115	GRUS;ST19;VV27; HG12+15
N7456	9.64	10.36	−0.68	−0.48	1504	115	GRUS;ST19;VV27; HG12+15
N0253	9.54	10.58	−0.96	−2.24	283	2	SCULPTOR;ST20;VV1; HG13
I0239	9.53	9.86	−0.49	0.23	783	9	N1023;ST21;VV7;HG67
N1087	9.56	10.48	−0.85	−1.05	1386	10	CETUS I;ST22;VV15; HG44+48
N1084	9.89	10.62	−0.64	−1.05	1386	10	CETUS I;ST22;VV15; HG44+48
N1376	10.04	10.87	−0.66	1.12	4019	14	HG47
I0342	9.79	9.88	−0.24	1.55	155	17	HG84
N1559	9.56	10.41	−0.82	−0.11	910	18	DORADO;N1566;ST3;VV16; HG3
I0529	10.04	10.38	−0.32	−0.22	2362	25	HG90
N2742	9.54	10.28	−0.74	−0.44	1541	26	N2768;HG80;VV41;TG6
N3052	9.85	10.77	−0.77	−1.00	3345	34	HG37
N3187	9.36	9.51	−0.42	0.40	1188	36	VV47;TG21;HG57
N3430	9.76	10.26	−0.49	1.32	1448	40	VV43;TG28;HG65;N3396
N3395	9.72	10.15	−0.49	1.32	1448	40	VV43;TG28;HG65;N3396
N3549	9.76	10.36	−0.59	−0.92	1883	42	URSA MAIOR I;VV28
N3338	9.75	10.18	−0.48	−0.15	929	44	LEO;ST27;VV9;TG27; VV11;HG56
N3956	9.59	10.00	−0.54	0.25	1459	52	HG33
N3938	9.48	10.26	−0.80	−0.06	878	54	URSA MAIOR I(S);TG28; VV32
N4273	9.71	10.51	−0.74	1.42	2125	59	VIRGO W;VV46;HG41
N4535	9.49	10.41	−0.89	1.08	915	64	VIRGO I(S');VV25; TG57;HG41

TABLE 2 (CONTINUED)

NGC/IC	log M_H	log L_B	$log\left[\frac{M_{HI}}{L_B}\right]_{cor}$	log d	VG	Group	REM
N5236	10.00	10.49	−0.41	−0.26	312	79	N5128;VV4;HG19; ST32
N4945	9.08	10.32	−1.22	−0.26	312	79	N5128;VV4;HG19;ST32
N5480	9.15	10.20	−1.10	−0.86	1912	86	HG72
N5427	9.77	10.74	−0.82	−0.04	2524	89	HG46
N5660	10.00	10.60	−0.51	−0.17	2399	94	N5676;VV37;TG91; HG73
N5673	9.81	10.20	−0.43	−0.17	2399	94	N5676;VV37;TG91; HG73
N6412	9.64	10.41	−0.74	1.28	1836	101	N6643;VV51;ST34
N6643	9.86	10.73	−0.74	1.28	1836	101	N6643;VV51;ST34
N6744	10.04	10.85	−0.62	0.32	0586	102	HG2
N5529	9.93	10.54	−0.54	−0.28	3448	91	TG86

However, neutral hydrogen is relatively easy to detect and we would expect that anomalies in the H I content would reflect anomalies in the total gaseous content of the galaxy (Haynes, Giovanelli and Chincarini 1984). Moreover, the ratio $M_{H\ I}/L_B$ has the advantage of being independent of the distance.

A possible problem with the ratio $M_{H\ I}/L_B$ as an indicator of deficiency in the gaseous content is that for a given morphological type a dependence on the luminosity may exist (Balkowski 1973). Such an effect was not confirmed by Shostak (1978) and by Bottinelli, Gouguenheim and Paturel (1980) while a positive evidence was found by Haynes and Giovanelli (1984) and Giuricin *et al.* (1985). In order to test if such an effect was present in our sample, we distributed our galaxies following the morphological type, inside bins of Δlog L_B = 0.25 and then we computed the average $M_{H\ I}/L_B$ ratio for each bin. Figure 1 shows a plot of the resulting data for the Sc's. Inspection of this plot shows clearly an anti-correlation between the ratio $M_{H\ I}/L_B$ and the B-luminosity of the galaxy. However, when we consider the Sb galaxies (Figure 2) this is not so evident. If only the last 5 bins are considered then a significant anti-correlation is also found. However, a constant $M_{H\ I}/L_B$ ratio is consistent when we consider the sample as a whole. In the case of the Sc galaxies, it is clear that this

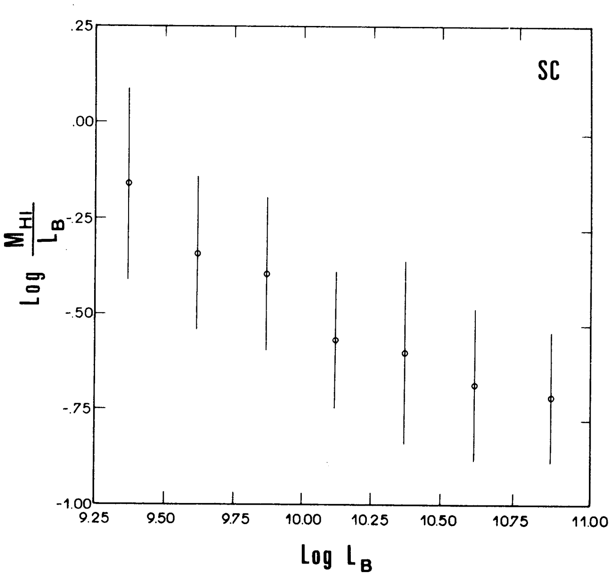

Fig. 1. Hydrogen mass to luminosity ratio as a function of luminosity for the Sc sample.

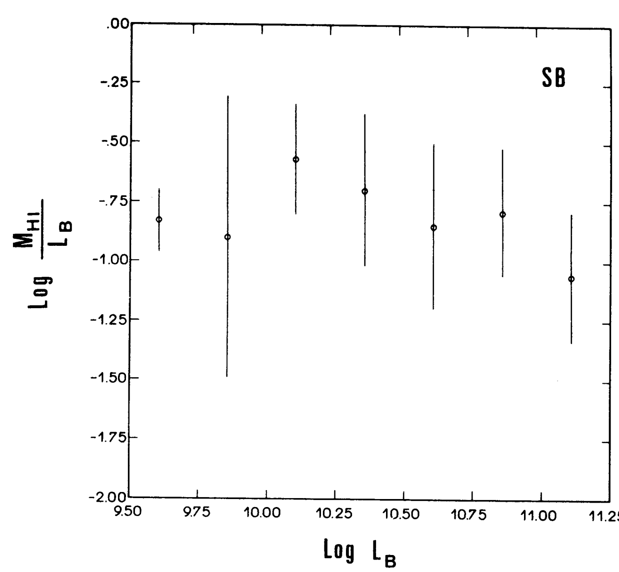

Fig. 2. Hydrogen mass to luminosity ratio as a function of luminosity for the Sb sample.

luminosity effect must be corrected before any analysis of the gaseous content variation should be performed. In order to do that, we fitted our data through a relation of the form

$$\log \langle M_{H\ I}/L_B \rangle = a \log L_B + b \quad . \qquad (2)$$

Then we considered the medium of the luminosity distribution as being the characteristic luminosity of Sc's and we reduced the observed $M_{H\ I}/L_B$ ratio to the expected one if all the objects had the same luminosity. This was done using equation (2). For the Sb's the same reasoning was applied. If the sample as a whole is considered no correction is necessary because the data is compatible with a constant $M_{H\ I}/L_B$ ratio. Another possibility is to apply an equation similar to (2) using the last five bins as we have already mentioned. In fact, in the case of Sb's we have considered both possibilities.

Once the "corrected" $M_{H\ I}/L_B$ ratios were obtained by the above procedure, we distributed the galaxies inside bins of galaxian density. For the Sc's we have considered bins $\Delta\log D = 0.40$ wide while for Sb's the bins were slightly smaller, namely, $\Delta\log D = 0.35$. For both morphological types we calculated the average $M_{H\ I}/L_B$ ratio for each density bin. Figures 3 and 4 give a plot of our data for Sc and Sb galaxies respectively. In the case of Sb's we give only the plot corresponding to no luminosity correction since practically the same result is obtained in the other situation.

IV. DISCUSSION

The analysis of Figure 3 indicates that in spite of a span in the galaxian density of about 4 decades, no significant variation of the luminosity-corrected $M_{H\ I}/L_B$ ratio for Sc's is detected. The same conclusion is also obtained from the analysis of the Sb's data. In fact the last three bins suggest a slight decrease of the $M_{H\ I}/L_B$ ratio with the galaxian density (Figure 4). However, the uncertainties in the bins are larger and such a tendency cannot be considered statistically significant. We emphasize also that this possible effect in the Sb's sample would occur at galaxian densities around 10 Mpc^{-3}. However, in the Sc's sample, densities 50 times higher are present and no effect is seen, supporting our point of view that we are observing only a statistical flunctuation in the high density bins of the Sb's data.

On the other hand, the absence of environment effects puts some constraints on the density of any intergalactic gas. In this case, since no effects due to the ram-pressure are observed, the density of a possible intergalactic medium satisfy

$$n_i < n_H (\sigma_H^2/\sigma^2)$$

where n_H is the average gas density inside galaxies, σ_H is turbulent velocity dispersion of such a gas and σ is the mean square galaxian velocity inside groups. From our data and assuming as typical values $n_H \sim 1\ \text{cm}^{-3}$, $\sigma_H \sim 10\ \text{km s}^{-1}$, one obtains $n_i < 3 \times 10^{-4}\ \text{cm}^{-3}$. This estimate agrees with the conclusions by Giuricin *et al.* (1985).

Our results can be summarized as follows: no gas deficiency was found in a sample of 84 Sb and 95 Sc galaxies located inside groups. Any intergalactic gas present in those groups must have a density smaller than 3×10^{-4} cm^{-3}.

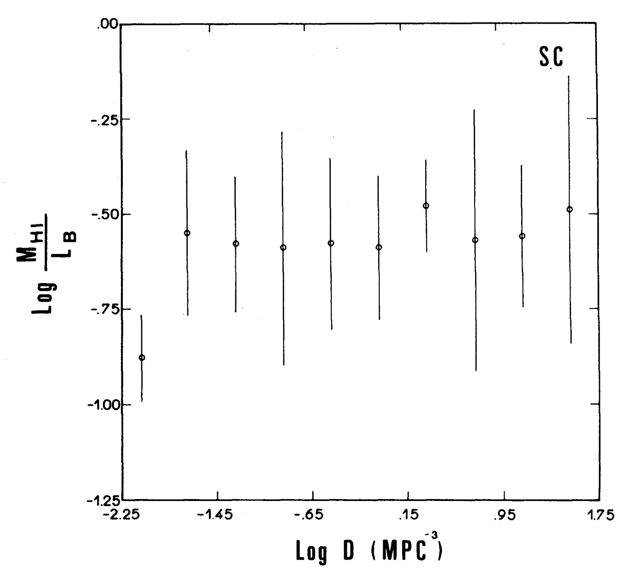

Fig. 3. The corrected H mass to luminosity ratio as a function of the galaxian density for the Sc sample.

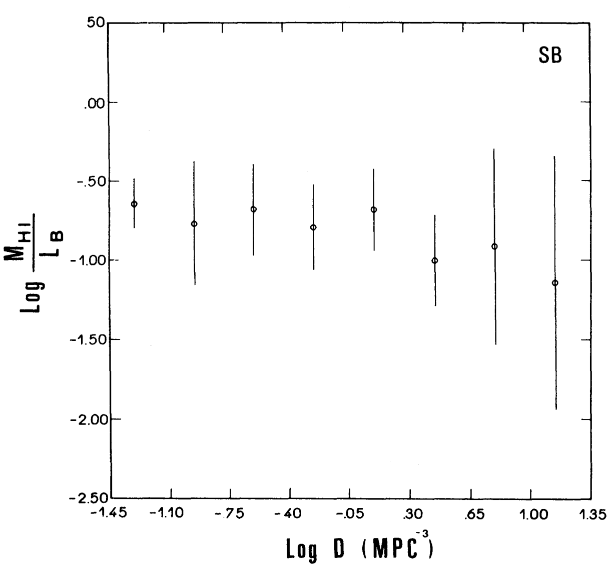

Fig. 4. The corrected H mass to luminosity ratio as a function of the galaxian density for the Sb sample.

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