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HI-search for nearby dwarf galaxies

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Abstract. We present 26 new candidates (mainly from the POSS II) for nearby dwarf galaxies of which 17 have been detected in the 21-cm line from neutral hydrogen with the 100-m radiotelescope at Effelsberg. There is one new dwarf member of the IC342/Maffei group (Camelopardalis B), three new members each of the NGC6946 and the NGC672/IC1727 group. These seven galaxies ($\sim$ 25% of our search list) are within the range of the Kraan-Korteweg-Tammann sample (i.e. $v_0 \leq 500\,km\,s^{-1}$).

Key words: galaxies: irregular – galaxies: evolution – galaxies: ISM – radio lines: galaxies

1. Introduction

The knowledge of the galaxian luminosity function is important for problems like formation and evolution of galaxies in general. Complete samples of galaxies in well defined areas of space are a possible approach in this direction. For a cluster sample the complete survey of the Virgo cluster to a faint limit in apparent magnitude (Binggeli et al. 1985) is the best example available (HI-data of this sample e.g. Huchtmeier and Richter 1989, the Virgo dwarf sample Hoffman et al.,1987). For the field sample the catalog of galaxies with $v_0 \leq 500km\,s^{-1}$ (Kraan-Korteweg and Tammann 1979 [KKT], HI data : e.g. Huchtmeier and Richter 1988) is the first extensive data collection of this kind which has been extended recently by Schmidt et al. 1993, and Karachentsev 1994. It is evident that this catalog becomes incomplete at its magnitude limit especially as it is an all-sky survey. For the obscuration in the zone of avoidance it never will be complete. The idea of this paper was to improve the completeness of the field sample for faint dwarf galaxies.

Inspection of the POSS-II and ESO/SERC films and in some cases also of the POSS-I by Karachentseva & Karachentsev (1997, KK hereafter) revealed a relatively large number of additional (240) faint images of 'dwarf' galaxies. They allowed for a lower angular diameter limit, about 0.5 arcmin (instead of 1.0 arcmin in case of the DDO sample). They suppose that a significant part of the objects they found may be dwarfs within $v_0 \leq 500km\,s^{-1}$. We selected 26 objects for this pilot programme to search for HI-emission in order to determine the radial velocities of these objects and to study their global parameters.

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2. H I-observations

Observations were performed using the 100-m radiotelescope at Effelsberg which has a half power beam width of 9.3' at the wavelength of 21cm. The 1024-channel autocorrelator was split into four filter banks (256 channels each) using a bandwidth of 6.25 MHz which yielded a resolution of 6 km/s or 10 km/s after Hanning smoothing. The four filter banks were used with a frequency offset of 5 MHz each in order to search a larger velocity range (-500 to 4000 km/s). A typical observing time of 30 min per source yielded a r.m.s. noise of 6 mJy (the system noise was 30K). An ON-source position was combined with an OFF-source position every 5 minutes. This total power mode improves the baseline behavior of the spectra. Regular measurements of well known continuum sources were used to control pointing and calibration of the telescope. Every two to three hours a well known line source (e.g. dwarf galaxies) was used as a system check. The toolbox software of the MPIfR was used for the data reduction. The observed spectra were corrected for moderately curved baselines (first and second order polynomials only) which should not introduce additional errors for the derived velocity and flux measurements as we observed narrow lines only.

3. Data

From our searchlist of 26 we detected 17 galaxies. These HI profiles are shown in Fig. 1. Each profile is the average of a number of independant observations. Interferences change their intensities with time. For example, there is an interference in the profile of A 0147+2840 at $\sim$3480 $km\,s^{-1}$, whereas the line at $3840km\,s^{-1}$ is visible in all subscans with the same intensity. This is the case for all the other narrow profiles in Fig. 1.

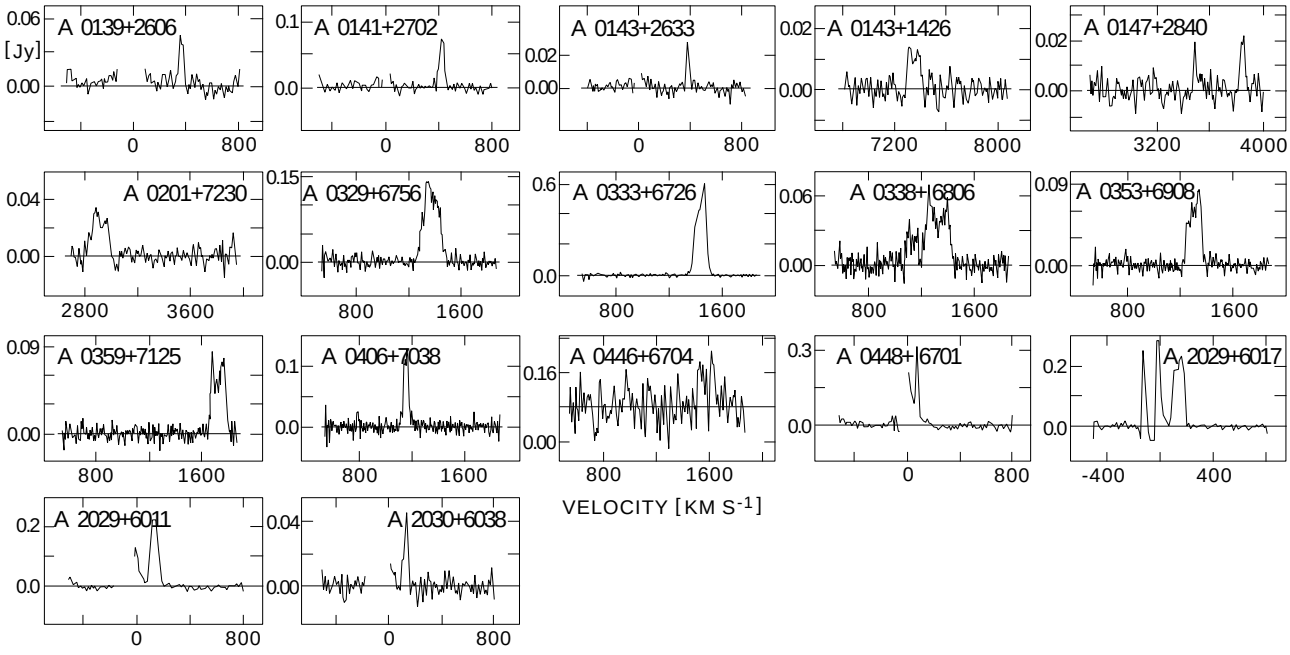

Fig. 1. HI profiles of the 17 detected galaxies observed with the 100-m radio telescope at Effelsberg which has a half power beam width of 9.3 arcmin at a wavelength of 21-cm. Local HI-emission around 0 $km\,s^{-1}$ has been left out as it is much stronger than the weak extragalactic emission. The spike at 3480$km\,s^{-1}$ in the spectrum of A 0147+2840 is due to interference.

Narrow profiles in Fig. 1 correspond to dwarfish galaxies (i.e. $M^{0,i}_{B,T}$ fainter than -15), i.e. the first three, A 0448+6701, and the last two profiles in Fig. 1. In these profiles we cut the local HI emission (in fact the difference of the local emission between the ON and the OFF position - total power mode) as it was much stronger than the faint extragalactic emission. The profile of A0448+6701 is situated on the flank of the local emission. This has been taken into account while measuring the HI-flux of this dwarf galaxy by interpolation of a polynomial of third order to the *baseline* adjacent to the galaxy's profile. Optical data in Table 1 are from KK; optical dimensions and the total apparent magnitudes were estimated by eye from the POSS taking into account other known LSB galaxies from the RC3 [1] as calibrators. A typical accuracy of the estimates is 20% for diameters and 0.5 mag for magnitudes. The entries in Table 1 are as follows : R.A. and Dec.(1950.0) in columns 1 , the optical dimensions in column 2 in arcmin,a rough morphological type (Irregular/Spheroidal) in column 3, the catalog number (from KK) and notes in column 4. The HI data follow; the measured HI flux (column 5), the observed peak of the line and its rms error in column 6 (for non detections only the rms noise is shown), the heliocentric radial velocity derived from the midpoint of the line at 25% and 20% of the peak and its error (column 7), and the linewidths at a level of 50%, 25%, and 20% of the line peak (column 8).

Derived global parameters of the detected galaxies are presented in Table 2, the galaxy name (i.e. the catalog no. from KK) in column 1, the total blue magnitude B_t in column 2, and the estimated absorption correction A_b in column 3. Using this correction and the RC2 [2] correction for inclination we get for the corrected total blue magnitude

$B^{0,i}_t = B_t - A_b - 1.2log(a/b)$,

where a and b are the optical dimensions (Table 1). Distances have been derived using a Hubble constant H_0 = 75 $km\,s^{-1}\,Mpc^{-1}$. For L8, L9, L10 we adopted the same distance as measured by Tikhonov & Drozdowsky (1997) for NGC 672/IC 1727, and for L148, L149, and L150 the same distance as for NGC 6946 (Sharina, Karachentsev, Tikhonov, 1997), distances are given in column 4. As the optical diameters given in Table 1 exceed D_{25} by 20% on average we reduced the optical diameter a and b by 20% to be in the D_{25} system and applied a correction for absorption and for inclination

$D_0 = log\,a + 0.09\,A_b - 0.2\,log(a/b)$.

The linear diameter $A_{0,i}[kpc]$ follows in column 5, the absolute magnitude $M^{0,i}_{b,t}$ in column 6. The total H I mass (column 7) has been calculated by

$M_{H\,I} = 2.355\,10^5\,D^2\,\int S_v dv$,

where D is the distance in Mpc and $\int S_v dv$ is the integrated HI-flux in $Jy\,km\,s^{-1}$. The total mass M_T (column 8) has been derived (following HR1) by

$M_T = const\,D\,a_0\,\Delta v^2_{0,i}$,

where D is the distance in Mpc, a_0 the corrected optical diameter in arcmin, const=7500, and $\Delta v_{0,i}$ the corrected edge-on linewidths at 50% of the peak flux. The relative HI-mass M_{HI}/M_T, the mass-to-luminosity ratio M_T/L_B, and the rel-

[1] de Vaucouleurs et al. 1991

[2] de Vaucouleurs et al. 1976

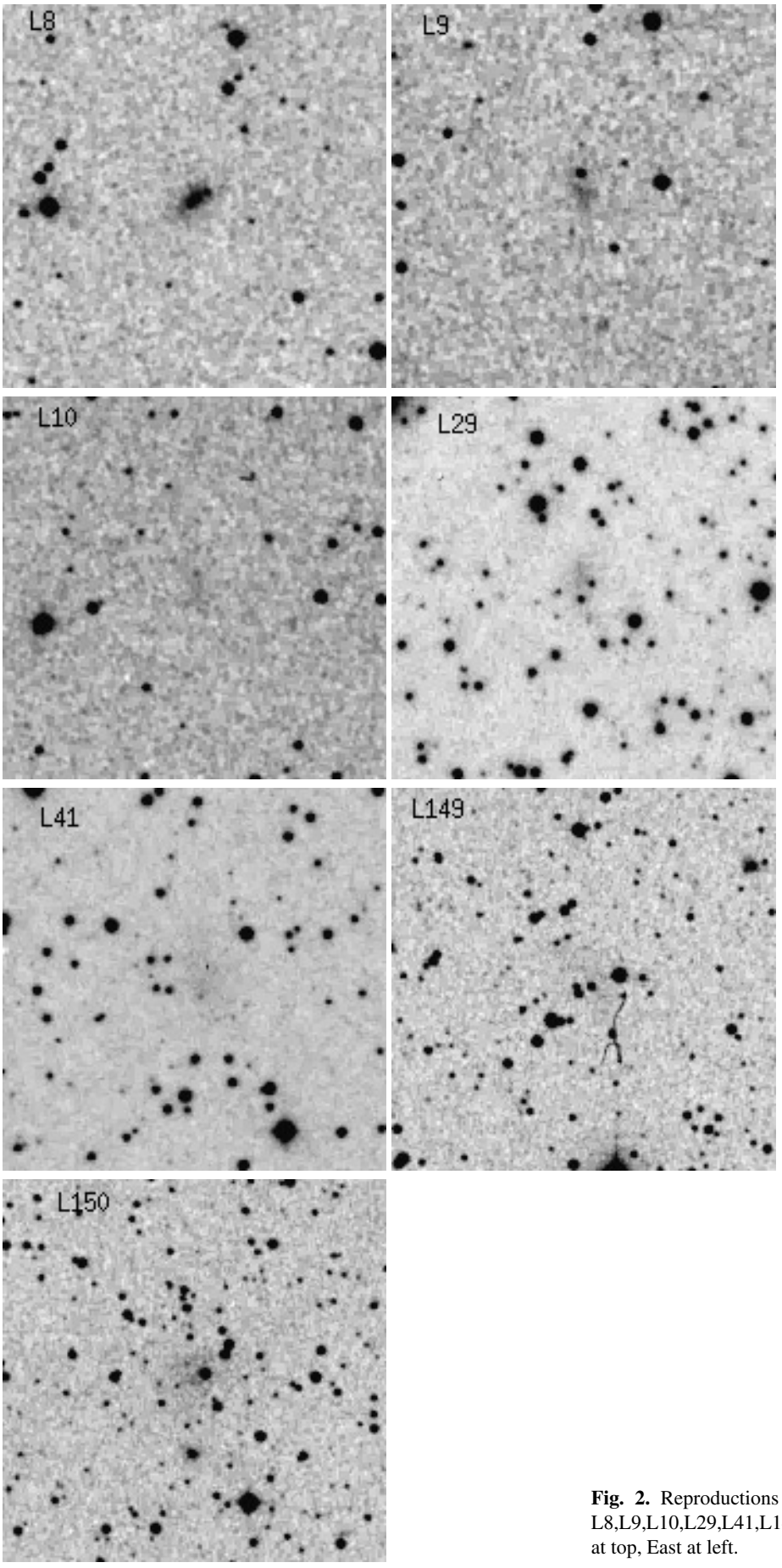

Fig. 2. Reproductions from the digital POSS-I: detected dwarfs: L8,L9,L10,L29,L41,L149, and L150. Each chart is 5 x 5 arcmin, North at top, East at left.

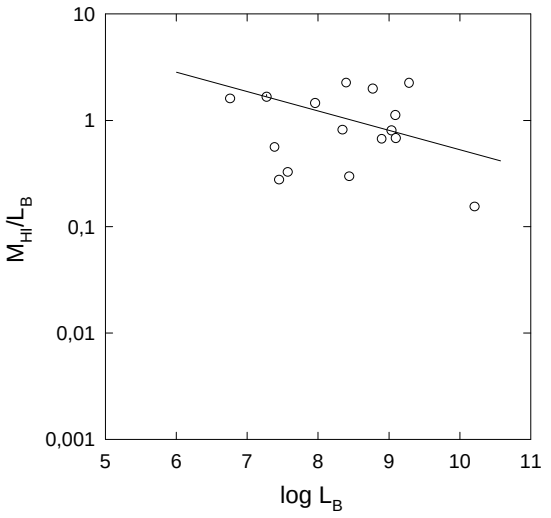

Fig. 3. The relative content of neutral hydrogen M_{HI}/L_B of the detected galaxies is plotted versus blue luminosity L_B. The solid line represents the sample of nearby galaxies (HR1).

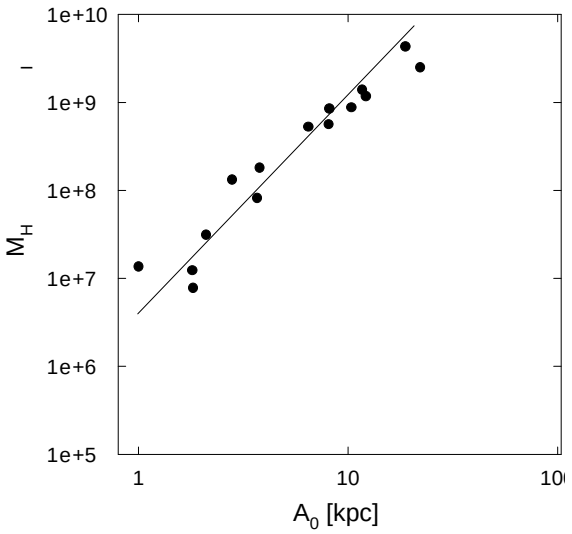

Fig. 4. The mass of neutral hydrogen M_{HI} versus linear diameter A_0 is given for the detected galaxies of our 'dwarf' sample. The solid line represents the sample of nearby galaxies (HR1).

ative HI content M_{HI}/L_B follow in columns 9 to 11, respectively.

Reproductions from the digital POSS-I are given for a number of detected dwarf galaxies in Fig.2. These figures are centered to the galaxies and show a field of 5 by 5 arcmin (North at top, East at left).

4. Discussion

The average relative H I mass $M_{H\,I}/M_T$ of our galaxy sample of 0.34 ± 0.04 is a value typical for late-type disk galaxies (e.g. HR1). This is also true for the mass to luminosity ratio M_T/L_B. The relative HI content $M_{H\,I}/L_B$ often is used in the discussion of global parameters of galaxies. Our sample has a mean $M_{H\,I}/L_B$ of 1.05±0.18 which is identical within the errors with the mean value (1.08±0.15) for type 10 galaxies from the nearby galaxy sample (KKT, Huchtmeier and Richter 1988). The luminosity function of both samples is quite similar, most galaxies being in the blue magnitude range -12 ... -17. In a recent paper Huchtmeier et a. (1996) discussed a trend in M_{HI}/L_B with the degree of isolation of the galaxies for the luminosity range $8.2 \leq log\, L_B \leq 9.2$ showing increasing values of M_{HI}/L_B for increasing degree of isolation. In Fig. 3 we plot the $M_{H\,I}/L_B$ values of our sample vs. blue luminosity. The solid line represents the sample of the nearby galaxies. This plot demonstrates the agreement between both samples. However, there is a tendency for fainter dwarfs (i.e. $6.6 \leq log\, L_B \leq 8.2$) to have lower M_{HI}/L_B values - 0.98 ± 0.24 - compared to the sample of nearby galaxies - 1.86 ± 0.42 - for the same range in luminosity [3]. This difference (two to four sigma) is only marginal . As all these faint dwarfs of our sample are members of nearby groups of galaxies this tendency of showing lower M_{HI}/L_B values than the comparison sample would be compatible with the assumption that they might have lost some of their gas. HI deficiency in groups of galaxies has been observed by Garcia-Barreto et al. 1994. It might be interesting in this context to investigate a cluster sample for means of comparison. The mean value of the Virgo dwarf sample (Hoffman et al. 1987) for the same luminosity range ($6.6 \leq logL_B \leq 8.2$) is M_{HI}/L_B = 1.33 ± 0.20 which is not significantly different from the 0.98±0.24 for the present sample of dwarf galaxies.

Among global parameters of disk galaxies the total HI mass correlates well with the linear optical diameter. This relation is shown in Fig.4 where we plot $M_{H\,I}$ vs. $A_{0,i}$. Again the solid line represents the sample of nearby galaxies. The agreement between our sample and the sample of nearby galaxies (KKT) is good. These results suggest that the detected objects are indeed normal dwarf galaxies at the assumed distances.

In the present sample there are 7 galaxies ($\sim$ 25%) which fall within the limits of the KKT (i.e. $v_0 \leq 500 km\, s^{-1}$). If this result can be extrapolated to all galaxies of the Karachentsev catalog (KK) we would expect to increase the known spiral and irregular galaxies in the KKT by about 25%.

5. Conclusions

We searched 26 new candidates for nearby galaxies, from which 17 were detected in the 21-cm line of HI. There is a new member of the IC342/Maffei group (Camelopardalis B) and three new members each of the N6946 and the NGC672/IC1727 groups. These seven galaxies ($\sim$ 25% of our search list) are within the range of the Kraan-Korteweg-Tammann sample of nearby galaxies (i.e. $v_0 \leq 500\, km\, s^{-1}$). A discussion of global parameters leads to the conclusion that the galaxies of our present

[3] There is some overlap with the HR1 sample of nearby galaxies and a recent paper (Hoffman et al. 1996) presenting mapped irregulars with good agreement in total HI fluxes

Table 1. Observational data

RA (1950.0) DEC	Dimension a b arcmin	Type	Notes	HI-flux $[Jy\,km\,s^{-1}]$	S_{max} [mJy]	HI velocity $[km\,s^{-1}]$	HI linewidth $[km\,s^{-1}]$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
01 39 29.5 +26 06 57	0.7 x 0.4	Ir	L8	1.33	40±7	357±9	31 45 52
01 41 54.0 +27 02 14	1.6 x 0.6	Ir	L9 LSB	3.04	74±6	420±4	36 56 60
01 43 53.6 +26 33 07	0.6 x 0.18	Ir	L10 VLSB	0.90	27±6	368±4	25 37 40
01 43 55.7 +14 26 33	1.0 x 0.7	Ir	L11 UGC 1242	1.10	18±7	7356±5	105 124 126
01 47 10.5 +28 40 03	0.7 x 0.5	Ir	L12	0.92	25±7	3841±4	38 48 50
01 52 30.2 +27 42 34	0.8 x 0.3	Ir	L13 LSB		±7		
01 57 18.1 +28 35 26	0.6 x 0.3	Ir	L14 LSB		±9		
01 57 22.0 +67 30 36	1.3 x 0.9	Sph?	L15 ELSB		±6		
02 01 46.3 +72 30 23	0.8 x 0.8	Ir	L16	3.28	34±6	2918±7	128 143 155
03 18 53.2 +62 36 27	1.8 x 0.9	Ir	L24		±5		
03 29 09.1 +67 56 36	2.0 x 0.8	Ir	L25 LSB,#7 (BK,85)	18.17	140±9	1372±3	144 174 180
03 33 44.4 +67 26 00	2.0 x 0.7	Ir?	L26 LSB,#8 (BK,85)	50.74	590±7	1434±1	92 117 124
03 37 26.8 +19 35 30	0.8 x 0.7	Ir	L28 LSB		±8		
03 38 25.0 +68 06 11	2.2 x 0.3	Ir?	L29 LSB,#12 (BK,85)	11.46	68±6	1320±5	179 210 228
03 40 23.7 +67 42 26	2.5 x 1.7	Ir	L31 VLSB		±6		
03 53 22.5 +69 08 24	1.1 x 0.6	Sph?	L34 LSB,#19 (BK,85)	7.78	83±5	1302±2	117 134 137
03 59 34.8 +71 25 44	1.2 x 0.5	Ir	L35 VLSB,#21 (BK,85)	6.83	69±5	1734±2	120 133 136
04 06 44.0 +70 38 18	0.9 x 0.4	Ir	L37 LSB	4.6	110±7	1159±2	42 54 59
04 39 44.4 +61 15 47	0.6 x 0.6	Ir?	L39 VLSB		±7		
04 46 40.8 +67 04 29	0.6 x 0.4	Sph?	L40 LSB	0.79:	12±4	1581±28	
04 48 03.3 +67 01 02	2.2 x 1.1	Ir	L41 LSB	3.67	168±11	75±5	23 41
19 16 17.0 +63 52 54	1.5 x 1.2	BCG	L147 HSB,NGC 6789		±10		
20 29 12.1 +60 17 00	2.2 x 0.5	Ir	L148 UGC 11583	20.00	244±6	127±2	90 104 107
20 29 31.9 +60 11 03	1.6 x 0.8	Ir?	L149 VLSB	14.62	223±8	126±2	64 87 94
20 30 33.5 +60 38 34	0.9 x 0.9	Sph?	L150 VLSB	1.36	45±5	132±3	27 47 50
20 33 46.2 +60 55 12	1.5 x 0.9	Ir?	L151 ELSB		±8		

BK objects are from Börngen and Karachentseva 1985

LSB low surface brightness

VLSB, ELSB : very low surface brightness, and extremely low surface brightness.

L8 It is situated at 94 arcmin SW from the centroid of NGC 672/IC 1727, a dwarf companion of the pair.

L9 At 40 arcmin W from the above pair, companion.

L10 At 37 arcmin SW from the above pair, companion.

L11 UGC 1242 at a redshift of 7356$km\,s^{-1}$ is a background object and with M_B=-20 a giant compared to the other galaxies.

L13 L14 Probably $v \geq 4000 km\,s^{-1}$.

L15 Without brightness gradient, probably PLN of B_t=19mag.

L24 Irregular boxy shape with some knots, looks like a nearby dwarf.

L25, L26, L29, L34, L35 together with UGC 2800 (1175 $km\,s^{-1}$), UGC 2813 (1392 $km\,s^{-1}$), UGC 2827 (1523 $km\,s^{-1}$, UGC 2855 (1207 $km\,s^{-1}$), UGC 2890 (1165 $km\,s^{-1}$), NGC 1485 (1085 $km\,s^{-1}$), and UGCA 81 (1496 $km\,s^{-1}$) they probably belong to a loose group with a radial velocity of 1350 $km\,s^{-1}$, a velocity dispersion of 150 $km\,s^{-1}$, and a diameter of 6^0.

L28 A dwarf, but probably with a velocity bejond 4000 $km\,s^{-1}$.

L31 Probably a peripheric patch of a spiral arm of IC 342.

L39 Probably distant with a velocity bejond 4000 $km\,s^{-1}$.

L40 marginal detection

L41 CAMELOPARDALIS B is a new member of the IC 342/Maffei group of galaxies.

L147 Resolved into stars with CCD at the 6-m telescope, a probable member of the Local Group.

L149 At 6' from UGC 11583 (L148), confusion?, at 38 arcmin NW of NGC 6946.
Offset positions 9' N E and W of L 148 show no significant emission, but 9' S got 7.3 $Jy\,kms^{-1}$. The flux of a point source at the position of L149 would have to be corrected to 12.35 $Jy\,kms^{-1}$ which would change its M_{HI}/L_B to 0.28.

L150 At 47 arcmin NW of NGC 6946, companion.

L151 Reflecting nebula?

Table 2. Derived parameters for the detected galaxies

galaxy name (KK)	B_t mag	A_b mag	distance D Mpc	diameter $A_{0,i}$ kpc	absolute magnitude mag	HI mass $[10^8 M_\odot]$	total $[10^8 M_\odot]$	M_{HI}/M_T	M_T/L_B $[M_\odot/L_\odot]$	M_{HI}/L_B $[M_\odot/L_\odot]$
L8	16.6	0.2	6.6	1.0	-13.0	0.14	0.34	0.40	1.4	0.56
L9	17.1	0.2	6.6	2.1	-12.7	0.31	0.76	0.41	4.0	1.65
L10	18.5	0.2	6.6	0.8	-11.4	0.09	0.12	0.76	2.1	1.60
L11	15.3	0.2	98.0	22.1	-20.0	24.9	118	0.21	0.7	0.15
L12	18.4	0.2	51.0	8.1	-15.5	5.64	5.8	0.98	2.3	2.26
L16	19.0	2.5	39.0	12.2	-16.5	11.7	206	0.06	34.6	1.98
L25	17.0	2.5	18.0	11.7	-17.2	13.9	71.4	0.19	5.8	1.12
L26	17.0	2.5	19.0	8.8	-17.7	43.1	40.4	1.05	2.1	2.24
L29	17.7	2.5	18.0	10.4	-17.0	8.74	85.7	0.10	7.8	0.80
L34	17.2	2.5	17.0	6.5	-16.8	5.3	31.1	0.17	3.9	0.67
L35	17.0	2.0	23.0	8.2	-17.3	8.51	35.1	0.24	2.8	0.68
L40	17.7	1.5	21.0	3.7	-15.6	0.82	30	0.03	10.8	0.30
L41	16.1	1.5	3.0	1.9	-13.2	0.08	0.24	0.32	0.9	0.28
L148	15.6	1.6	6.2	3.8	-15.4	1.81	9.4	0.19	4.2	0.81
L149	16.5	1.6	6.2	2.6	-14.4	1.32	3.8	0.35	4.1	0.33
L150	17.1	1.6	6.2	1.8	-13.5	0.12	1.3	0.10	3.4	0.35

sample are not different to the sample of nearby galaxies. However, there is some indication that the dwarfish galaxies (i.e. $6.6 \leq log\, L_B \leq 8.2$) of the present sample all of which are members of galaxy groups, might be HI deficient compared with the comparison sample (HR1).

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