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Search for emission-line galaxies towards nearby voids. List 2*

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Abstract. We present a second list of emission-line galaxies (ELGs) discovered during our survey of nearby voids. The project aims to answer the question of whether the giant galaxies are fair tracers of the large scale structure and whether the voids are really empty. This paper is the third of a series of papers dedicated to this project. The survey was based on a sample selected from the HQS (Hamburg Quasar Survey) - IIIa-J digitised objective prism plates and the main selection criteria was the presence of emission-lines, mainly of the [OIII] $\lambda5007$ line.

Positions, heliocentric redshifts, detected emission-lines and finding charts are provided for ELGs in a region North of the Coma Supercluster, $30.5^\circ < \delta < 45.5^\circ$, centred around $13.5^{\rm h}$. Most of the galaxies presented here are from the extreme faint candidates, close to the detection limit of the photographic plates. Brighter galaxies detected among the candidates of the same region were discussed in Popescu et al. (1996) (Paper I). A few redshifts of other emission line galaxies observed since the publication of Paper I are also included; in total, we present new redshifts for a total of 47 galaxies.

Key words: large scale structure — galaxies: redshift — surveys — galaxies: irregular

1. Introduction

Our search for emission-line galaxies (ELGs) towards nearby voids has been described in detail by Popescu et al. (1996) (Paper I) and Popescu et al. (1997) (Paper II). The project belongs to a larger one that has the aim of finding faint galaxies within the voids (Hopp et al. 1995; Kuhn et al. 1997). In summary, we have undertaken a program to search for dwarf galaxies in voids. The motivation of the project was to examine the question of whether the void regions represent real structures, or whether they merely appear as such due to selection effects. We have especially selected nearby voids which were very well defined in the distribution of normal giant galaxies, in order to overcome some of the limitations of previous surveys. Since there was a hint that emission-line galaxies tend to be less clustered, we chose to search for emission-line objects, but with the aim of finding mainly HII galaxies or BCDs (blue compact dwarf galaxies).

The candidates were selected from the objective prism plates taken from the Hamburg Quasar Survey (HQS) (Hagen et al. 1995). An automated procedure was applied to the low-resolution digitised objective-prism spectra, based on two parameters, the slope of the continuum and the "intensity" of the integrated spectra (see Paper I). The selected candidates were afterwards rescanned with high resolution and the final selected spectra were visually inspected for the presence of emission-lines. The candidates are mainly selected on the presence of the [OIII] $\lambda5007$ line. In Paper I we presented the catalogue of all emission-line galaxies found with the above mentioned selection criteria and we will refer to this as "List 1". This means that objects fainter than our threshold in "intensity" were not considered. The cut in brightness produces some loss of very faint ELGs, having very little continuum and almost all the flux in the emission-lines. In order to prevent the latter incompleteness we also scanned the photographic plates for such faint objects. We observed all the new candidates with follow-up spectroscopy and produced a second list of ELGs that is given in the present paper. We will refer to this catalogue as "List 2". The extra survey was done only for one of our regions - Region 3 from Paper I (a region North of the Coma Supercluster,

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* Based on observations obtained at the German-Spanish Observatory at Calar Alto, Almeria, Spain.

$30.5° < \delta < 45.5°$, centred around 13.5^{h}). The results concerning the spatial distribution of all the galaxies found in our Region 3 ("List 1" and "List 2") were presented in Paper II. From the estimates of the expected number of void galaxies we concluded that we did not find an underlying homogeneous void population.

2. Follow-up spectroscopy

We observed all the candidates from the "List 2" during one observing run, between 20-24 May 1996. The observations were carried out with the CAFOS (The Calar Alto Faint Object Spectrograph) at the 2.2 m telescope at the German-Spanish Observatory at Calar Alto (Almeria, Spain). The details of the observations are given in Table 1. The observations from May 1996 were done in excellent weather conditions (the photometry being better than 5%) and therefore the campaign was not dedicated to the follow-up spectroscopy of the new candidates but mainly to the spectrophotometry of a bigger sample of emission-line objects, including objects from Paper I. Because the main goal was accurate flux determination, we used a 4″ slit widths, which on the the other hand increased the error in the redshift determination of the new candidates. Thus the error in redshift of the objects presented in this paper is bigger than the error of the objects from Paper I.

Table 1. The details of the spectroscopic observations from May 1996

Detector	Lor-80
Pixel Size (μ)	15
Slit width (″)	4
PA	90.
Pixel number	1024×1024
Grism	9
Dispersion (Å/pixel)	5.6
Resolution (Å)	17
Spectral Range (Å)	$3600 - 9000$

The data were reduced using the MIDAS routines. The frames were biased and flatfield-corrected. For the extraction of the 1-dimensional spectra from the 2-dimensional data, the optimal extraction algorithm of Horne (1986) was used. The spectra were rebinned to a linear wavelength scale using a third or fifth order polynomial fitted to the dispersion curve of the comparison spectra. A flux calibration was applied, including the correction for the atmospheric extinction using the mean extinction values for Calar Alto. Finally the wavelength scale was checked by comparison with the night-sky lines. A more detailed description of the reduction procedure is given by Stickel et al. (1993).

Once fully reduced, the emission lines in each spectrum were measured by fitting a Gaussian Curve. The quoted redshifts were derived as means of the redshifts determined from the individual strong lines, and the errors of the redshifts were calculated as error of the mean. The observed redshifts were further corrected for the motion of the Earth and transformed in heliocentric redshifts. The internal errors from the May 1996 campaign are around $\Delta z = 0.0002$. In order to estimate the external errors due to the 4″ slit width we compared the redshifts of some galaxies observed also in a previous campaign (see Paper I) with a 2″ slit width. We obtained a total error of $\Delta z = 0.00035$. For the few galaxies with absorption lines the errors are larger, up to $\Delta z = 0.0007$.

3. The catalogue

The observed objects are listed in Table 2. The table is organised as follow:

- **Column (1)** gives the name of our objects, which are designated by the prefix HS (from Hamburg Survey), followed by the first four digits of the 1950.0 right ascension and declination.
- **Column (2)** gives alternative designations for those galaxies contained in other catalogues. The abbreviations are explained in the List of Abbreviations.
- **Columns (3)** and **(4)** give the 1950.0 positions. The coordinates are derived from the Hamburg direct plates and have an accuracy of ±2″.
- **Column (5)** gives the heliocentric redshifts.
- **Column (6)** contains a flag S (from selection) that gives the selection criteria used to select the candidates from the objective prism spectra: E for emission candidate (first priority) and B for blue candidate (second priority) (see Paper I).
- **Column (7)** contains special remarks.

Table 2 contains 39 galaxies, of which 33 are ELGs and 6 are galaxies with absorption lines. The later came only accidentally into our sample, as failures of our selection procedure. Three objects were previously known as IRAS sources and of these, two were also radio sources. From the 39 galaxies from our Table 2 only three were already known in the literature with available redshifts. These objects were therefore not reobserved, and the redshift given in the table is taken from literature.

One object from our catalogue, HS1337+3941 happens to be a very nearby dwarf galaxy. With a redshift of $z = 0.0025$, this galaxy entered into our sample only as a second priority object (see Paper I for the selection flag S = E). It has a very faint [OIII] 5007 line and would be better detected by an Hα survey.

Finding charts of all our newly discovered objects can be found in Fig. 1. We also give the finding charts of

Table 6. The details of the spectroscopic observations from Aug. 1995

Detector	TEK	TEK
Pixel Size (μ)	24	24
Slit width ($''$)	2.4	3.6
PA	various	various
Pixel number	1024×1024	512×512
Grating	#10	#5
Dispersion (Å/pixel)	0.64	0.89
Resolution (Å)	1.3	2.5
Spectral Range (Å)	4820−5471	4762−5672

Table 8. Candidates with available redshifts from literature, observed with the purpose of testing the redshift accuracy

name	other name	our z	reference z	difference in z
HS0019+0450	UM 27	0.0345	0.0340	0.0005
HS0022+0014	-	0.0139	0.0139	0.0000
HS0025+0443	UM 40	0.0044	0.0045	0.0001
HS0832+6624	MRK 93	0.0176	0.0176	0.0000

some of our objects that were previously known as IRAS sources. The finding charts were prepared by means of the Palomar Sky Survey plates, digitised and distributed on CD-ROM by the Space Telescope Science Institute. Fields are $10' \times 10'$. North is up, and east is to the left.

The identified emission (absorption) lines of all the newly discovered galaxies are listed in Table 3 while those objects which are certainly stars are listed in Table 5.

On our long-slit spectra we found some further emission-line objects projected near to our targets. These galaxies had good enough signal-to-noise to be fully reduced and they are listed in Table 4. They were not detected on the Hamburg objective plates because their redshift is higher than $z = 0.078$, which is the limit for which the [OIII] λ5007 line can be detected due to the cut-off of the IIIa-J emulsion at 5400 (see Paper I for selection effects). These galaxies are designated by the prefix HS followed by the first four digits of the 1950.0 right ascension and declination, plus the suffix N (from neighbours). Their finding charts can be found in Fig. 2, lower panel.

4. Appendix

In this appendix we present a few ELGs that were selected from our Region 1 (see Paper I) (the region of the Pisces-Perseus Supercluster) and Region 2. These objects were observed after the publication of the first catalogue and therefore were missed from our "List 1".

The observations were done in August 1995 with the Cassegrain Twin Spectrograph at the 3.5 m telescope at Calar Alto, as a back-up of an observational campaign not dedicated to our project. The details of the observations are given in Table 6 while in Table 7 we list the name of the ELGs, alternative designations (for those objects contained in other catalogues), their coordinates (equinox 1950.0), heliocentric redshifts and emission-lines seen in their spectra. The abbreviations for alternative designations can be found in the List of Abbreviations used for the Table 2. The data reduction follows the same procedure as described in Sect. 2. The errors in the redshifts are around $\Delta z = 0.0001 - 0.0002$. In order to have an external check of our redshift determination we also observed a few candidates that had redshifts in the literature. In Table 8 we give the names of the galaxies observed together with their velocities, both measured and from literature. In the last column we indicate the difference between our values and the reference one. Besides UM27, for which we obtained a big difference, the rest show differences up to 0.0001 in z. The finding charts of the newly discovered objects can be found in Fig. 2, upper panel.

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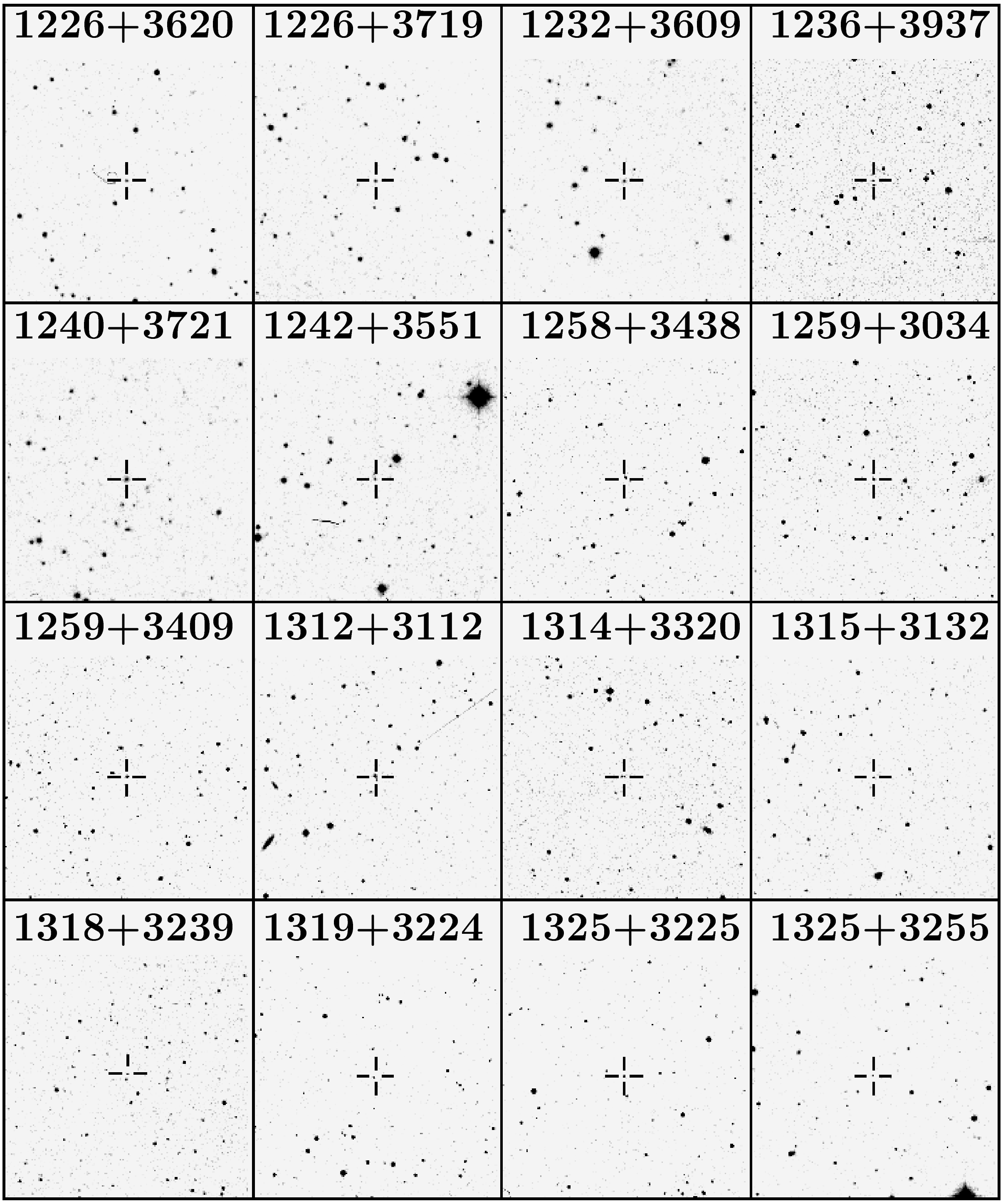

Fig. 1. Finding charts prepared from the Digitised Palomar Sky Survey. Fields are $10' \times 10'$. North is up, and east is to the left

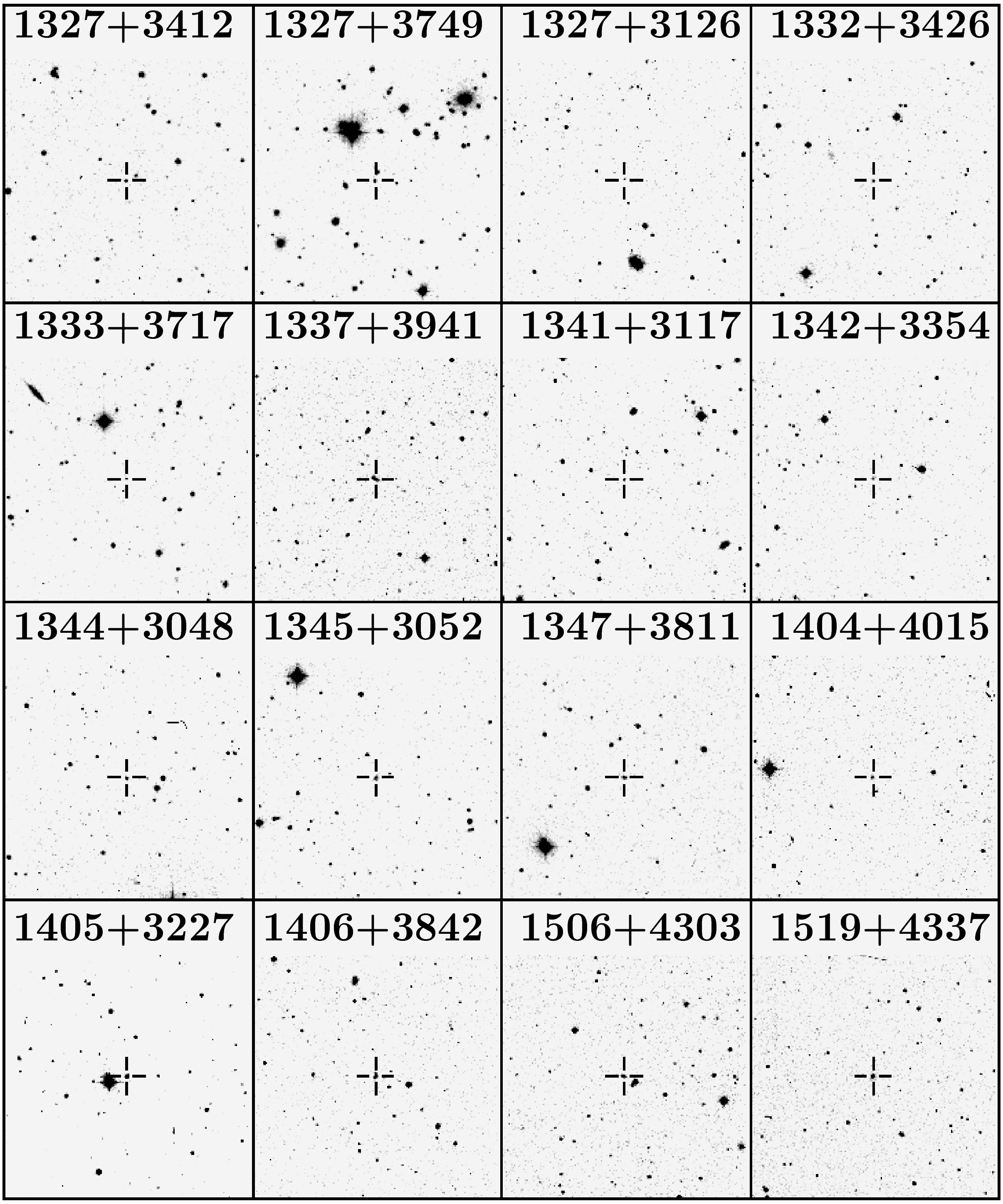

Fig. 1. continued

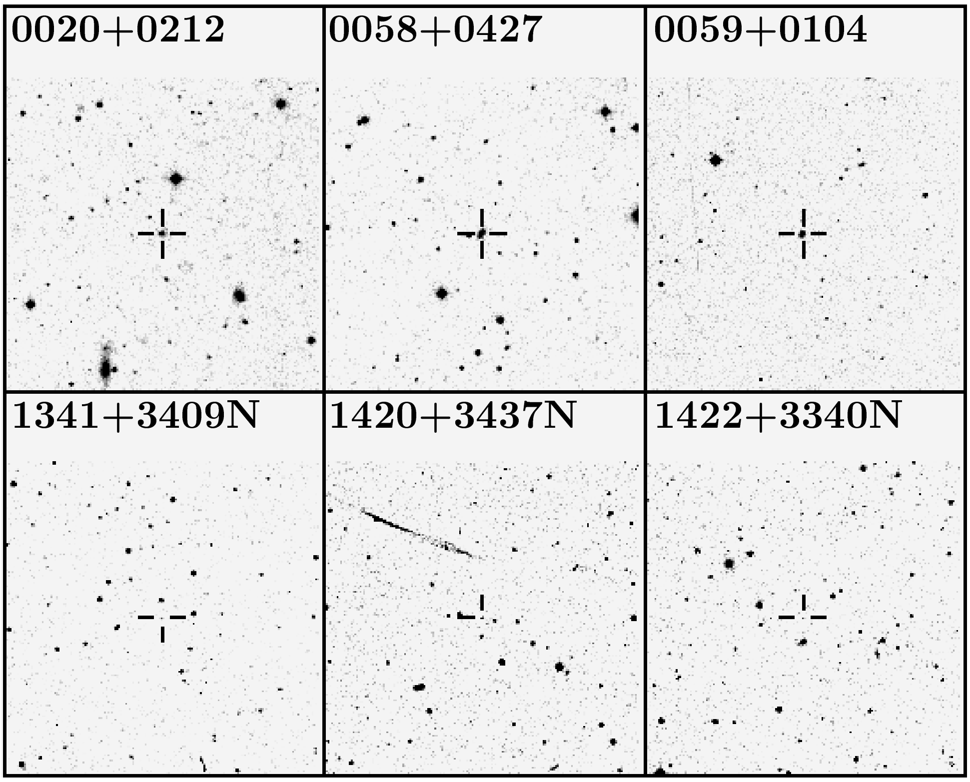

Fig. 2. Finding charts prepared from the Digitised Palomar Sky Survey. Fields are $10' \times 10'$. North is up, and east is to the left

Table 2.

(1) object name	(2) other names	(3) R.A.	(4) Decl.	(5) redshift	(6) S	(7) remarks
HS1226+3620		12 26 38.6	+36 20 55	0.0680	E	
HS1232+3609		12 32 09.4	+36 09 59	0.2529	E	
HS1236+3937		12 36 55.5	+39 37 33	0.0184	E	
HS1240+3721		12 40 49.0	+37 21 33	0.0218	B	
HS1240+3755	IRAS 12409+3755	12 40 58.6	+37 55 23	0.0860	B	IrS
	NPM1G +37.0370					
	FIRST J124322.5+373858					Radio S
HS1242+3551		12 42 45.2	+35 51 34	0.1589	E	
HS1258+3438		12 58 22.2	+34 38 15	0.0248	E	
HS1259+3034		12 59 15.9	+30 34 35	0.1268	B	abs
HS1259+3409		12 59 21.7	+34 09 33	0.1089	E	abs
HS1310+3801	PC 1310+3801	13 10 32.3	+38 01 04	0.0230	E	
HS1312+3112		13 12 18.4	+31 12 54	0.0205	E	*
HS1314+3320		13 14 32.0	+33 20 59	0.0515	B	
HS1315+3132		13 15 15.9	+31 32 51	0.0315	E	
HS1318+3239		13 18 44.0	+32 39 58	0.0435	E	
HS1319+3224		13 19 00.2	+32 24 07	0.0182	E	
HS1325+3225		13 25 20.1	+32 25 23	0.0504	E	
HS1325+3255		13 25 59.1	+32 55 27	0.0263	E	
HS1327+3412		13 27 16.7	+34 12 03	0.2510	E	
HS1327+3749		13 27 25.6	+37 49 33	0.0543	E	
HS1327+3126		13 27 32.0	+31 26 38	0.0568	E	
HS1327+3135	UGC 08496	13 27 59.3	+31 35 25	0.0161	E	G Group
	VV 069					
	KUG 1327+315					
	CGCG 161 − 071					
	CGCG 1328.0+3135					
	MCG +05 − 32 − 031					
	WAS 73					
	[SMB88] 0742					
	LGG 350:[G93] 005					
HS1332+3426		13 32 27.9	+34 26 20	0.0220	E	
HS1333+3717		13 33 34.6	+37 17 03	0.0569	E	
HS1337+3941		13 37 20.7	+39 41 10	0.0025	E	
HS1341+3117		13 41 32.8	+31 17 51	0.0293	E	
HS1342+3354		13 42 03.1	+33 54 31	0.0054	E	
HS1344+3048		13 44 08.9	+30 48 07	0.1694	B	abs
HS1345+3052		13 45 27.0	+30 52 04	0.0768	E	
HS1347+3811		13 47 02.4	+38 11 35	0.0103	E	
HS1404+4015		14 04 15.5	+40 15 04	0.1519	B	
HS1405+3227	IRAS 14057+3227	14 05 45.4	+32 27 01	0.0864	E	IrS
	IRAS F14057+3227					abs
	FIRST J140756.9+321249					Radio S
HS1406+3842		14 06 38.2	+38 42 41	0.1549	B	abs
HS1424+3836	CG 0428	14 24 25.8	+38 36 26	0.0218	E	
	[SP82] 13					
HS1440+3120	CG 1252	14 40 00.2	+31 20 50	0.0525	E	
HS1445+3801	IRAS F14456+3801	14 45 36.1	+38 01 36	0.0353	E	IrS
	CG 0543					
	[SP82] 23					

Table 2. continued

(1) object name	(2) other names	(3) R.A.	(4) Decl.	(5) redshift	(6) S	(7) remarks
HS1506+4303		15 06 42.2	+43 03 24	0.0404	B	**
HS1509+4409		15 09 56.8	+44 09 28	0.0275	B	**
HS1519+4337		15 19 40.8	+43 37 57	0.1347	E	abs
HS1529+4512	CG 0745	15 29 28.7	+45 12 10	0.0231	E	

Remarks on Table 2:

∗ The galaxy HS1312+3112 has a galactic star superimposed on the North-Eastern side of its image.

∗∗ HS1506+4303 and HS1509+4409 were observed with the Twin Spectrograph, with the same set-up as given in Table 6 (see Appendix).

List of Abbreviations

abbrev.		reference
CG	Case Galaxy	8, 11
CGCG	Catalogue of Galaxies and of Cluster of Galaxies 1968	16
FIRST	Faint Images of the Radio Sky at Twenty Centimeters	1
IRAS	Infrared Astronomical Satellite Catalogs 1988. The Point Source Catalog	3
IRAS F	Infrared Astronomical Satellite Catalogs 1990. The Faint Source Catalog	5
KUG	Kiso Survey for UV Excess Galaxies	12
LGG	Lyon Group of Galaxies Catalog	2
MCG	Morphological Catalogue of Galaxies	14
NPM	Lick Northern Proper Motion Program	4
PC	Palomar Transit Grism Survey	9
[SMB88]	Slezak, Mars, Bijaoi et al. (1988)	10
[SP82]	Sanduleak & Pesch (1982)	7.
UGC	Uppsala General Catalogue of Galaxies 1973	6
VV	Vorontsov-Velyaminov (1959, 1977), Atlas and Catalog of Interacting Galaxies	13
WAS	Wasilewski (1983)	15

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Table 3. The emission and absorption lines detected in the spectra of the observed objects

object name	emission lines	absorption lines
HS1226+3620	[OII], Hβ, [OIII], [OIII], Hα, [SII]	
HS1232+3609	[OII],Hβ, [OIII], [OIII], HeI, Hα+[NII], [SII]	CaK, CaH, Hδ, $G_{\rm band}$
HS1236+3937	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, Hα, [SII]	
HS1240+3721	Hα	
HS1240+3755	[OII], Hβ, [OIII], [OIII], Hα+[NII], [SII]	CaH, Hδ, $G_{\rm band}$, Mgb, NaD
HS1242+3551	[OII], Hβ, [OIII], [OIII]	CaK, CaH, Hδ, $G_{\rm band}$, Hγ, Mgb, NaD, Hα
HS1258+3438	[OII], [NeIII], Hδ, Hγ, Hβ, [OIII], [OIII], HeI, Hα, [SII]	
HS1259+3034		$G_{\rm band}$, Mgb, NaD
HS1259+3409		CaK, CaH, $G_{\rm band}$, Hβ, Mgb, NaD
HS1312+3112	[OII], Hβ, [OIII], [OIII], Hα, [SII]	
HS1314+3320	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, Hα, [SII], [AIII]	
HS1315+3132	[OII], [NeIII], Hϵ, Hδ, Hγ, Hβ, [OIII], [OIII], HeI, [OI], Hα+[NII], HeI, [SII], [AIII]	
HS1318+3239	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, Hα+[NII], HeI, [SII], [AIII]	
HS1319+3224	[OII], [NeIII], Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, Hα, [SII]	
HS1325+3225	[OII], Hγ, Hβ, [OIII], [OIII], HeI, Hα, HeI, [SII]	
HS1325+3255	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, [OI], Hα, [SII]	
HS1327+3412	[OII], Hβ, [OIII], [OIII], Hα, [SII]	CaK, CaH, Hδ, $G_{\rm band}$, FeI
HS1327+3749	Hα, [SII]	CaK, CaH, $G_{\rm band}$, Mgb
HS1327+3126	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, [OI], [OI], Hα, HeI, [SII], HeI, [AIII], [OII], [AIII], [AIII]	
HS1332+3426	[OII], [NeIII], Hγ, Hβ, [OIII], [OIII], HeI, [OI], Hα, [SII], [AIII], [OII]	
HS1333+3717	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, [OI], Hα, HeI, [SII], HeI, [AIII], [OII], [AIII]	
HS1337+3941	[OIII], Hα, [SII]	CaK, CaH, Hδ, $G_{\rm band}$, Hγ
HS1341+3117	[OII], [NeIII], Hβ, [OIII], [OIII], Hα, [SII]	
HS1342+3354	[OII], Hδ, Hβ, [OIII], [OIII], HeI, Hα, HeI, [SII]	
HS1344+3042		$G_{\rm band}$, Mgb, NaD
HS1345+3052	[OII], Hα, [SII]	
HS1347+3811	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, [OI], Hα, [SII], HeI, [AIII]	
HS1404+4015		CaK, CaH, $G_{\rm band}$, Mgb, NaD
HS1406+3842		CaK, CaH, $G_{\rm band}$, Mgb, NaD
HS1424+3836	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, [OI], Hα, [SII], [AIII]	
HS1440+3120	[OII], [NeIII]+Hζ, Hϵ, Hδ, Hγ+[OIII], Hβ, [OIII], [OIII], HeI, [OI], Hα, HeI, [SII], [AIII]	
HS1506+4303	Hβ, [OIII]	
HS1509+4409	Hβ, [OIII], [OIII]	
HS1519+4337		CaK, CaH, $G_{\rm band}$, Hβ, Mgb, NaD
HS1529+4512	[OII], Hγ, Hβ, [OIII], [OIII], Hα, [SII]	

The complete sequence of emission lines listed in Table 3 (wavelengths given in Å): [OII] (blend) 3727.45, [NeIII] 3868.76, Hζ 3889.05, Hϵ (blend [NeIII], [OII]) 3970.07 (3967.47, 3967.40), Hδ 4101.6, Hγ 4340.3, [OIII] 4363.21, Hβ 4861.2, [OIII] 4958.92, [OIII] 5006.85, HeI 5875.99, [OI] (blend with [SII]) 6300.32 (6312.1), [OI] 6363.81, [NII] 6548.2, Hα 6562.9, [NII] 6583.6, HeI 6678.1, [SII] (blend) 6723.6, HeI 7065.3, [AIII] 7135.8, [OII] (blend) 7319.9, 7330.2, [AIII] 7751.02, [AIII] 8036.3

Table 4.

(1) object name	(2) R.A.	(3) Decl.	(4) redshift	(5) emission lines
HS1341+3409N	13 41 50.9	+34 09 14	0.2813	[OII], Hα
HS1420+3437N	14 20 59.1	+34 37 42	0.1308	[OII], Hβ, [OIII], Hα
HS1422+3340N	14 22 53.8	+33 40 09	0.2427	Hα

Table 5. List of identified stars

object name	coord.	B	type	abs. lines
HS1328+3524	13 28 01.5 +35 24 34	18.1	mid-G	$G_{\rm band}$, Mgb
HS1344+3640	13 44 15.1 +36 40 07	19.5	mid-F	Hδ, Hγ, Hβ, Mgb, Hα
HS1410+3352	14 10 30.5 +33 52 46	19.5	M0-M2	NaD
HS1513+4028	15 13 53.6 +40 28 20	19.5	late F or early G	$G_{\rm band}$, Hγ, Hβ, Mgb, NaD, Hα
HS1516+4441	15 16 19.1 +44 41 47	19.3	mid M	
HS1524+4255	15 24 50.1 +42 55 31	19.7	A or early F	Hα

Table 7.

(1) object name	(2) other names	(3) R.A.	(4) Decl.	(5) redshift
HS0008+0443		00 08 45.9	+04 43 42	0.0389*
HS0017+0018	MCG +00-02-002	00 17 13.5	+00 18 48	0.0177
	NPM1G +00.0010			
HS0020+0212		00 20 35.3	+02 12 58	0.0183
HS0053+0606	NPM1G +06.0043	00 53 07.3	+06 06 39	0.0401
HS0058+0427		00 58 33.5	+04 27 55	0.0300
HS0059+0104		00 59 57.6	+01 04 30	0.0164
HS0800+6141	UGC 04196	08 00 01.0	+61 41 21	0.0298
	KUG 0800+616			
	MCG +10-12-069			
	CGCG 287-037			
	CGCG 0800.0+6142			
HS0838+6253		08 38 45.2	+62 53 07	0.0051**

$*$ At the position of HS0008+0443 the NASA/IPAC Extragalactic Database (NED) reports an already known object, namely UM20. This object is assigned with a redshift of $z = 0.0830$ (reference: Terlevich et al. 1991), while we determined $z = 0.0389$. The galaxy observed by Terlevich et al. (1991) does not have emission lines, while our's has! Trying to understand this discrepancy we looked in the original paper and realised that the authors give other coordinates for UM20, namely $\alpha = 00^{\rm h}08^{\rm m}42.0^{\rm s}$, $\delta = 04^\circ 44' 00''$ (equinox 1950.0). These coordinates are obviously copied from the original UM list of MacAlpine et al. (1977). The coordinates given in NED for UM20 come from the identification of Kojoyan et al. (1982). Probably they do not refer to UM20, but to HS0008+0443. We can only speculate that this misidentification may come from the fact that on the Palomar Sky Survey there seems to be no object at the position indicated in the original list of MacAlpine et al. (1977) or Terlevich et al. (1991). In conclusion we consider that UM20 as observed by Terlevich et al. (1991) is not the same as the object identified by Kojoyan et al. (1982), and also differs from HS0008+0443. It is also obvious that the object observed by Terlevich et al. (1991) must have different coordinates than indicated in their paper.

$**$ The galaxy HS0838+6253 was already observed by us (Paper I), but with a very poor resolution. Here we give an improved redshift determination.