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New optical velocities of nearby dwarf LSB galaxies

D. I. Makarov[1,2], I. D. Karachentsev[1], and A. N. Burenkov[1,2]

[1] Special Astrophysical Observatory, Russian Academy of Sciences, N. Arkhyz, KChR, 369167, Russia
[2] Isaac Newton Institute of Chile, SAO Branch, Russia

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Abstract. We present radial velocities for nearby dwarf galaxy candidates found by Karachentseva & Karachentsev (1998) on the POSS-II films. Out of 118 observed objects, 88 have been detected in the H_α line. Their median radial velocity is 1750 km s^{-1}. A quarter of the galaxies belong to the Local Volume, having corrected radial velocities $V_{LG} < 500$ km s^{-1}. Some of them are members of the nearby groups around Maffei/IC 342, M 81, and NGC 6946.

Key words. galaxies: dwarf

1. Introduction

Kraan-Korteweg & Tammann (1979) defined the Local Volume (LV) as our extragalactic neighbourhood out to ~7 Mpc, which includes galaxies with radial velocities $V_{LG} < 500$ km s^{-1} corrected to the Local Group centroid. Apparently, the LV census becomes increasingly incomplete for smaller galaxies, especially those of low surface brightness (LSB). Over the last two decades many observational teams undertook efforts to update the LV sample. As a result, the original Kraan-Korteweg & Tammann list of 179 galaxies in the LV is now doubled. A significant number of nearby dwarf galaxies have been revealed in 1998–2001 by Karachentseva & Karachentsev after visual inspection of the POSS-II films. On the northern sky they found about 400 nearby galaxy candidates with angular diameters $a \gtrsim 0\farcm5$, being mainly LSB. All these objects were observed then in the HI line with the 100-m Effelsberg radio telescope (Huchtmeier et al. 1997, 2000a,b, 2003). About 50% of the galaxies were detected. Due to their median radial velocity, 1200 km s^{-1}, and the median HI line width, 60 km s^{-1}, most of the objects seem to be nearby dwarf galaxies, like DDO irregular galaxies. More than 50 of them are situated within the Local Volume.

As known, some nearby galaxies with heliocentric radial velocities V_h inside $[-300, +300]$ km s^{-1} remain still undetected or marginally detected in the HI line due to the Galactic emission. Gas rich galaxies can be undetected in HI when their radial velocities lie outside the interval $[-470, +3970]$ km s^{-1} used in the Effelsberg HI survey. Some target galaxies may be confused with their close bright neighbours, if their separations do not exceed the half power beam width of the Effelsberg telescope ($9\farcm3$ at 21 cm). For these reasons, measurements of optical velocities for nearby galaxy candidates are desirable.

Send offprint requests to: D. Makarov, e-mail: `dim@sao.ru`

2. Observations

The northern sky objects from the KK-lists (Karachentseva & Karachentsev 1998; Karachentseva et al. 1999, 2001) were observed with the 6-m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences with the prime focus CCD spectrograph UAGS in 2000–2002. A 1k×1k pixels CCD with a pixel size of 24 microns together with a 1302 grooves/mm grating provide a dispersion of 1.2 Å/pixel and a spectral resolution of 4 Å. The slit length and width were 150″ and 2″, respectively. A typical exposure time was 600–900 s in the H_α region. The image processing was carried out with the LONG context in the ESO-MIDAS reduction package. We obtained about 230 spectra for 118 objects.

3. Results

The basic parameters of the observed objects are given in Table 1. Its columns contain:

(1) galaxy number in the lists of Karachentseva & Karachentsev (1998) (KK); Karachentseva et al. (1999) (KKR); and Karachentsev et al. (2001) (KKH);

(2) equatorial coordinates at the 1950.0 epoch;

(3) major and minor angular diameters of the galaxy in arcmin, measured on blue plates;

(4) morphological type in the usual designations: Ir – irregular, Im – irregular magellanic, Sm – spiral magellanic; Sph – dwarf spheroidal, PN? – probable planetary nebula;

(5) mean surface brightness in a scale: H – high (22–23$^m/\square''$), L – low (~24$^m/\square''$), VL – very low (~25$^m/\square''$), and EL – extremely low (~26$^m/\square''$);

(6) heliocentric optical velocity and its internal error in km s^{-1}, measured from our spectra;

(7) heliocentric HI velocity and its error in km s^{-1}, measured by Huchtmeier et al. (2000a,b, 2003) and Karachentsev et al. (2001); blank lines in (6) and (7) mean that the objects were observed but not detected in H_α or HI, respectively;

Table 1. List of northern objects from the KK-lists observed with the 6-m telescope.

Object	RA (1950) Dec		*a b*	Type	SB	V_h(opt)	V_h(21cm)	*W*	Notes
1	2		3	4	5	6	7	8	9
KKH 3	00 43 00.3	−01 22 38	1.0 0.7	Ir	L	4071 ± 6		80	
KKH 6	01 31 44.0	+51 50 10	0.8 0.6	Ir	L	23 ± 5	53 ± 1		*
KKH 8	02 09 47.1	+10 05 56	1.3 0.7	Ir	L	1762 ± 4	1740 ± 4	30	
KKH 9	02 09 58.8	+32 34 49	0.8 0.5	Sph?	VL				
KKH 15	02 53 06.7	+36 56 02	0.7 0.4	Ir	L	5117 ± 9	−142 ± 2	110	*
KK 24	02 53 54.5	+17 15 25	0.6 0.4	Ir?	L	7188 ± 5			
KKH 16	02 56 11.2	+43 40 47	1.3 0.4	Ir	L	2186 ± 8	2148 ± 2	95	
KKH 17	02 58 42.1	+37 04 31	0.5 0.5	Ir	L	3722 ± 6		65	
KKH 18	03 00 00.5	+33 29 56	0.7 0.3	Ir	L	203 ± 5	216 ± 1		
KKH 20	03 19 54.1	+76 05 59	0.9 0.7	Ir	L	2165 ± 10	2131 ± 1	105	
KK 32	03 37 26.8	+19 35 30	0.8 0.7	Ir	L				
KKH 23	03 39 36.0	+38 27 30	1.1 0.8	Ir	L	5466 ± 7		75	
KK 35	03 40 23.7	+67 42 26	2.5 1.7	Ir	VL	−66 ± 3	105 ± 2		*
Cam A	04 19 26.1	+72 41 27	3.7 2.1	Ir	VL	−49 ± 3	−47 ± 1		
KKH 26	04 35 41.4	+06 59 39	2.4 0.6	Ir?	L	55 ± 4	−138 ± 3		*
KKH 28	04 41 07.0	+02 54 21	1.1 0.9	Ir	L	3483 ± 6	3508 ± 2		
KKH 29	04 53 27.3	+37 52 20	1.2 0.7	Ir	L	−39 ± 3			*
KK 49	05 39 00.7	+06 39 28	0.7 0.5	Ir	H	446 ± 5	455 ± 2	62	
KKH 33	05 49 39.1	+28 05 18	1.1 0.8	PN	L	49 ± 3			*
KKH 37	06 38 57.3	+80 10 35	1.2 0.8	Ir	L	11 ± 7	−148 ± 2		*
KK 60	07 20 23.0	+46 06 10	1.1 0.4	Ir	L	5965 ± 3			
KK 65	07 39 40.2	+16 40 47	0.9 0.5	Ir	H	288 ± 4	279 ± 1		
KKH 42	07 57 37.3	+86 16 49	0.8 0.5	Ir	L	1841 ± 3	1841 ± 2	35	
KK 67	08 00 34.9	+15 17 03	1.0 0.5	Ir	L	1991 ± 4			
KKH 46	09 05 58.5	+05 29 43	0.6 0.5	Ir	L	599 ± 3	598 ± 1		
KKH 51	09 27 24.2	+20 12 42	0.7 0.7	Ir	L		561 ± 1		
KKH 52	09 34 52.9	+27 47 35	0.6 0.3	Ir	L	1610 ± 3	1594 ± 2		
KKH 53	09 37 53.2	+00 16 15	0.8 0.7	Ir	L				
KKH 54	09 42 06.4	+32 28 07	0.9 0.9	Ir	L	546 ± 4	538 ± 1		
KK 78	09 47 23.6	+31 41 26	0.5 0.3	Ir	H	539 ± 4	520 ± 2	40	*
KK 80	09 50 45.0	+29 40 57	1.1 0.6	Ir	L	4405 ± 10		55	
KKH 58	10 04 23.3	+39 12 50	1.6 0.6	Ir	H	601 ± 5	587 ± 3		
KK 86	10 05 22.0	+30 44 09	1.0 0.6	Ir?	L	6273 ± 5			
KKH 60	10 13 22.0	+07 03 15	0.8 0.4	Ir	L	286 ± 8 :			*
DDO 82	10 26 47.0	+70 52 33	2.8 1.9	Im	H	56 ± 3			*
KKH 62	10 41 51.2	+54 28 09	0.6 0.4	Ir	L	1001 ± 3	999 ± 2		
KK 95	10 46 03.6	+64 59 20	2.2 1.7	Ir	VL				*
KKH 64	10 48 57.0	+03 43 10	1.2 0.9	Im	L	1034 ± 11	1070 ± 1		
KDG 73	10 49 28.2	+69 48 42	0.6 0.5	Ir	L		116 ± 1		*
KK 97	10 55 35.3	+20 22 35	0.7 0.5	Ir	L	4270 ± 8			
KK 100	11 11 22.9	+11 36 10	1.2 0.5	Ir	VL	2969 ± 5		80	
KKH 70	11 36 42.0	+60 26 55	0.9 0.4	Ir	H	1297 ± 7	−151 ± 1		*
KKH 74	11 52 38.6	+44 25 43	1.0 0.8	Ir	L		727 ± 3		
KK 118	11 58 42.9	+54 03 01	0.6 0.2	Ir	VL				
KKH 75	11 59 22.0	+62 55 13	0.7 0.4	Ir	L		−153 ± 1		*
KK 121	12 02 52.3	+43 59 13	1.1 0.6	Ir	VL				
KKH 76	12 08 50.6	+38 49 06	0.7 0.3	Ir	H	1078 ± 4	1081 ± 2		

Table 1. continued.

Object	RA (1950) Dec		*a b*	Type	SB	V_h(opt)	V_h(21cm)	*W*	Notes
1	2		3	4	5	6	7	8	9
KKH 77	12 11 42.1	+66 22 12	1.5 0.6	Ir	H	62 ± 3	68 ± 2		*
UGC 7298	12 14 02.2	+52 30 29	1.1 0.6	Ir	L		173 ± 1		*
KK 130	12 15 17.6	+28 45 09	0.6 0.3	Ir	L				
UGC 7369	12 17 08.1	+30 09 39	1.0 1.0	E	H				
KKH 79	12 17 28.0	+61 47 45	0.5 0.3	Ir	L		516 ± 1		
KK 155	12 35 13.0	+07 22 42	1.2 1.0	Ir	L	64 ± 5		80	*
KKH 82	13 10 43.1	+42 03 03	1.3 1.0	Ir	L				
KKH 83	13 22 38.0	+42 45 09	0.9 0.5	Ir	L	1096 ± 5	1105 ± 2	60	
KK 205	13 26 46.8	+67 53 28	1.2 0.5	Ir	L	991 ± 5		60	
KK 206	13 31 18.6	+49 21 30	1.0 0.6	Ir	H	591 ± 3	588 ± 2	35	
KKH 84	13 32 08.2	+09 02 56	1.1 0.7	Ir	H	1215 ± 3	1233 ± 3		
KK 209	13 35 52.8	+49 22 26	0.4 0.2	Ir	L				
KKH 86	13 52 02.2	+04 29 17	0.7 0.5	Ir	L		287 ± 1		
KK 225	13 52 51.5	+37 55 42	0.4 0.3	Ir	L	5843 ± 3			
KKR 1	13 55 16.8	+08 04 51	0.5 0.3	Ir	L				
KKH 87	14 13 32.9	+57 19 10	0.8 0.3	Ir	H	327 ± 5	320 ± 1		
KKR 4	14 13 57.0	+14 06 24	1.1 1.1	PN?	VL	−17 ± 2			*
KKR 7	14 14 44.3	+13 54 59	0.6 0.5	Ir	L	5013 ± 6		75	
KK 231	14 15 34.6	+23 18 21	0.8 0.3	Ir	L	4635 ± 4			
KKR 8	14 16 45.4	+03 21 08	1.3 0.8	Ir?	L				
KKR 10	14 30 10.3	+31 43 45	0.6 0.5	Ir	L	3415 ± 4			
KKR 14	14 52 09.8	+01 21 50	0.5 0.3	Ir	L	1830 ± 7			
KK 237	15 06 46.1	+56 27 03	0.7 0.5	Ir?	L		−177 ± 1		
KKR 17	15 08 46.1	+11 13 13	0.4 0.3	Ir	L	8273 ± 4		40	
KKR 19	15 20 44.7	+57 29 17	0.9 0.6	Ir	VL	765 ± 5			
KKH 88	15 50 51.0	+64 16 30	0.7 0.5	Ir	H	923 ± 3	933 ± 2	45	
KKR 24	16 11 25.5	+02 39 20	0.7 0.5	Ir	L				
KKR 25	16 12 37.3	+54 29 46	1.1 0.6	Sph?	L		−139 ± 1		
KKR 27	16 38 47.8	+22 00 45	0.4 0.2	Ir?	L	2819 ± 6			
KKR 28	16 43 30.2	+02 44 39	1.0 0.3	Ir?	VL				
KKR 29	16 46 13.8	+22 25 27	0.7 0.3	Ir	L	2871 ± 5			
KKR 31	16 56 27.4	+23 16 50	0.7 0.3	Ir	L				
KKR 32	16 59 25.4	+21 07 55	0.4 0.4	Ir	L	9436 ± 5			
KKR 35	17 28 26.6	+06 22 25	0.4 0.3	Ir	L				
KKR 36	17 43 45.0	+02 08 04	1.1 0.8	Im	L	2988 ± 6		40	
KKR 37	17 44 57.1	+22 21 47	0.7 0.4	Ir	L	6425 ± 13		110	
KKR 38	17 46 40.7	+26 13 01	0.8 0.4	Ir	L	2836 ± 13			
KKR 41	18 06 14.5	+00 22 10	1.8 1.6	PN?	EL				
KKR 43	18 14 54.8	+09 58 04	0.7 0.6	Ir	L	2189 ± 5			
KKR 44	18 33 48.0	+31 02 18	0.7 0.6	Ir	L	2931 ± 4			
KKR 46	19 35 28.2	+54 31 33	0.8 0.6	Ir	L	3734 ± 8	3779 ± 5		
KKH 90	19 41 50.0	+68 27 03	1.3 0.7	Ir?	VL		−139 ± 1		*
KKH 91	19 55 30.6	+04 39 17	0.9 0.5	Ir	L	−4 ± 2	−107?		*
KKR 47	19 55 54.0	+42 07 34	0.8 0.4	Ir	L	4766 ± 12			
KKR 48	19 57 14.7	+62 29 09	0.9 0.4	Ir	L	3165 ± 7	3158 ± 3		*
KKR 50	20 08 49.0	+10 46 42	0.6 0.4	Ir	L	7541 ± 8			
KKH 92	20 09 34.0	+65 56 03	0.5 0.2	Ir	L	2650 ± 11			
KKR 51	20 19 52.6	+52 18 26	0.7 0.3	Ir	L	2963 ± 5		40	

Table 1. continued.

Object	RA (1950)	Dec	a b	Type	SB	V_h(opt)	V_h(21cm)	W	Notes
1	2		3	4	5	6	7	8	9
KK 250	20 29 14.4	+60 16 22	1.8 0.8	Ir	VL	127 ± 5	127 ± 2		
KK 251	20 29 31.9	+60 11 03	1.6 0.8	Ir	VL	147 ± 6	130 ± 1		
KK 252	20 30 33.5	+60 38 34	0.9 0.9	Ir	VL	124 ± 6	138 ± 1		
KKR 53	20 30 49.1	+01 23 35	0.6 0.3	Ir?	L	5873 ± 8		120	
KKR 54	20 33 23.7	−01 29 25	0.7 0.3	Ir	L	1730 ± 7			
KK 254	20 33 46.2	+60 55 12	1.5 0.9	Ir?	EL				
KKR 55	20 44 15.2	+60 13 40	0.6 0.4	Ir	L	23 ± 5	32 ± 1		*
KKR 56	20 47 11.5	+58 25 56	0.7 0.4	Ir	L	−43 ± 8	−135:		*
KKR 57	20 46 36.5	+62 53 03	0.5 0.4	Ir	L	1553 ± 4			
KKR 58	20 48 19.1	+57 55 04	2.1 0.2	Sm	VL	2718 ± 10	2756 ± 2	170	
Ceph 1	20 49 52.0	+56 42 06	3.0 1.5	Sm?	VL	33 ± 7	58 ± 5		*
KKH 93	20 56 56.5	+62 09 15	0.5 0.3	Ir	L	2539 ± 11	−112 ± 2		*
KKR 59	21 02 02.8	+57 05 17	2.3 1.4	Ir	VL	−3 ± 4	17:		*
KKR 60	21 04 30.6	+57 00 15	0.7 0.5	Ir	VL	−14 ± 7			*
KKR 62	21 29 04.3	+52 28 24	1.1 0.6	Ir?	EL	−27 ± 6			*
KKR 63	21 53 40.8	+40 14 05	0.6 0.3	Ir	L	5679 ± 12			
KKR 64	21 58 05.5	+41 47 15	1.0 0.6	Ir	VL	4457 ± 8			
KKR 67	22 04 12.3	+37 06 31	0.4 0.3	Ir?	L	5798 ± 7		70	
KKR 72	22 33 48.4	+23 27 02	0.7 0.5	Ir?	L				
KKR 76	23 19 09.1	+25 49 55	0.6 0.4	Ir	L				
KKR 78	23 28 31.1	+22 09 57	0.5 0.4	Ir	L	6904 ± 6			
KKH 98	23 43 03.9	+38 26 24	1.1 0.6	Ir	L	−134 ± 4	−137 ± 1		
KKH100	23 49 51.4	+08 33 45	0.6 0.4	Ir	L	5530 ± 6		80	

Notes:
KKH 6. A probable member of the Maffei/IC 342 group.
KKH 15. This is UGC 2397, a distant peculiar galaxy. The HI emission is local.
KK 35. A peripheral star complex in IC 342, confusion with a strong HI from IC 342.
KKH 26. Not a galaxy, but a Galactic emission filament.
KKH 29. Probably not a galaxy, but a local HII region.
KKH 33. A planetary nebula PNG18.5+00.9.
KKH 37. Mailyan 16. The 21 cm velocity corresponds, apparently, to Galactic HII. A new Local Volume (LV) member? On its NE side there is a background galaxy with V_h = 13 220 km s^{-1}.
KK 78. UGC 5272b (Hopp & Schulte-Ladbeck 1991). The HI line confusion with UGC 5272 at 2′.
KKH 60. Should be confirmed as a probable new LV member. Two very faint emission details in two spectra.
DDO 82. A member of the M 81 group.
KK 95. UGCA 220 = Mailyan 58, reflection nebula.
KDG 73. A member of the M 81 group. V(HI) = −132 ± 6 km s^{-1} (NED), V(HI) = +116 ± 1 (Huchtmeier et al. 2003).
KKH 70. BCG, local HI.
KKH 75. Local HI?
KKH 77. UGC 7242, a peripheral member of the M 81 complex.
UGC 7298. A peripheral member of the M 81 complex, resolved with the HST.
KK 155. UGC 7795 = DDO 139 = VCC 1726, V_h(NED) = 62 ± 7 km s^{-1}.
KKR 4. F650-01. A planetary nebula.
KKH 90. A reflection nebula.
KKH 91. An emission nebula.
KKR 48. There is also Galactic H_α.
KKR 55. Comet-like, resolved with the 6-m telescope, companion to NGC 6946.
KKR 56. Galactic HI, resolved with the 6-m telescope, companion to NGC 6946.
Ceph 1. Companion to NGC 6946, HI velocity from Barton et al. (1999).
KKH 93. Local HI.
KKR 59. The HI velocity distorted with the Galactic HI. The resolved companion to NGC 6946.
KKR 60. An emission nebula or a new companion to NGC 6946?
KKR 62. A planetary nebula.

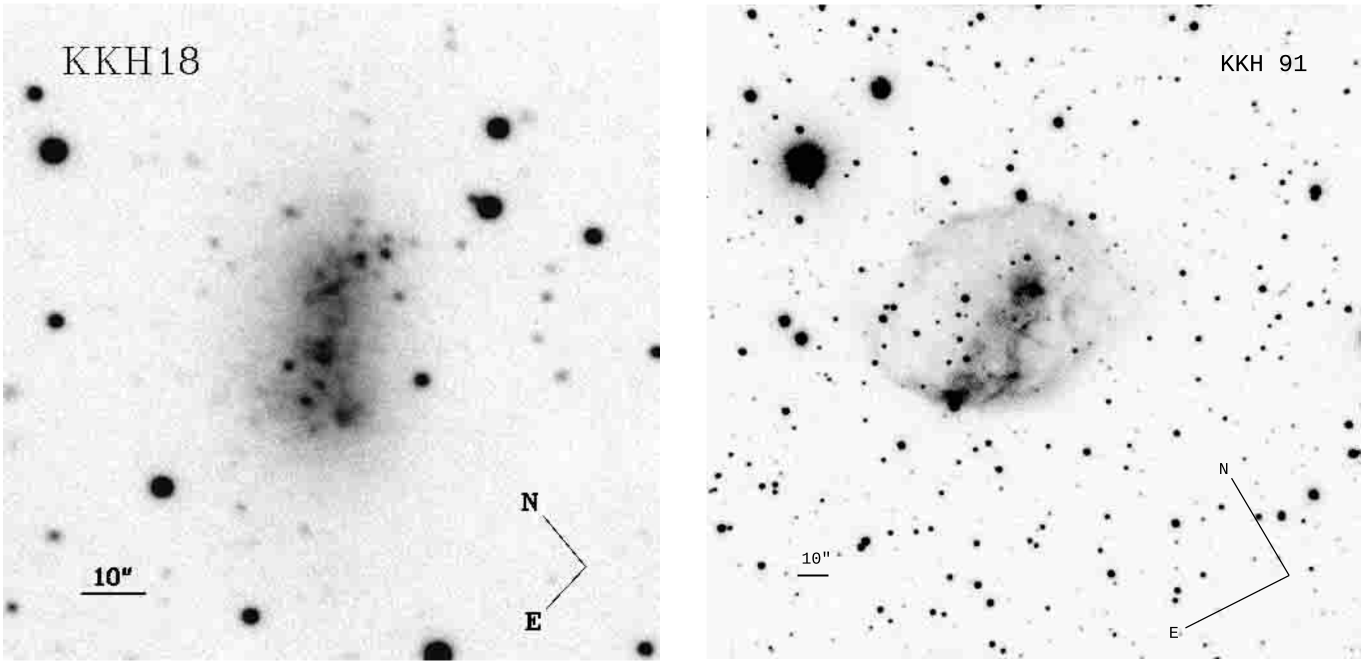

Fig. 1. CCD images of two LSB objects observed with the 6-m telescope: **a)** dwarf irregular galaxy KKH 18 imaged in the *V* band, **b)** KKH 91, a new planetary nebula, imaged in H-alpha filter by S. Kajsin.

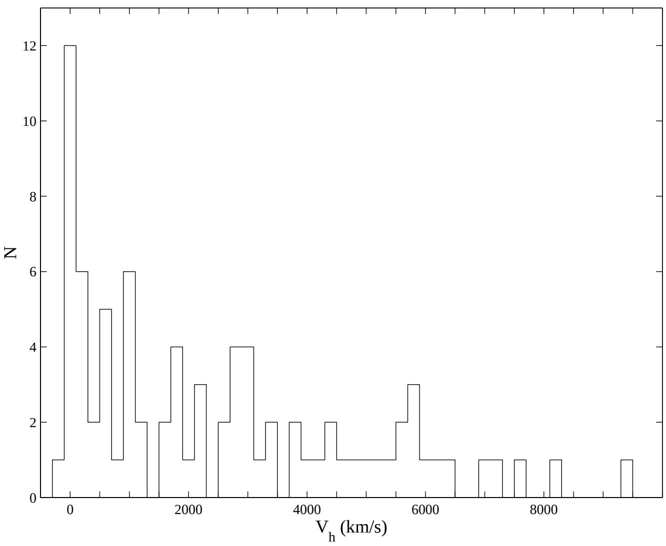

Fig. 2. Distribution of the observed galaxies according to heliocentric radial velocities in km s^{-1}.

(8) range of internal motions, W, in km s^{-1} measured along the slit position. It corresponds usually to a difference between maximal and minimal measured velocity in cases significant internal motions;

(9) asterisk addressing the table footnotes.

As an illustration, we present in Fig. 1 large-scale CCD images of two objects obtained with the 6-m telescope: a semi-resolved irregular galaxy, KKH 18, having $V_{\rm LG} = 372$ km s^{-1}, and KKH 91, which turns out to be a planetary nebula.

In total we obtained spectra for 118 nearby galaxy candidates, and 88 of them were detected in the H_α line. Figure 2 shows the object distribution according to their heliocentric radial velocity. The median velocity for the detected objects is 1750 km s^{-1}.

When six local Galactic objects: KKH 26, KKH 29, KKH 33, KKR 4, KKH 91, and KKR 62 with heliocentric velocities in a range of $[-39, +55]$ km s^{-1} are excluded, the median velocity of the sample increases to 1920 km s^{-1}. Therefore, the majority of the observed galaxies are true nearby dwarf galaxies situated inside the Local supercluster.

From 34 galaxies with optical as well radio velocities we obtained the mean-square velocity difference $\sigma(V_{\rm opt} - V_{\rm HI}) =$ 19 km s^{-1}, and the mean velocity difference $\langle V_{\rm opt} - V_{\rm HI}\rangle =$ -3 ± 3 km s^{-1}, showing a good agreement between H_α and HI velocity measurements.

The derived optical spectra allow us to clarify the nature of some objects that have been marginally detected before (see Table footnotes). For instance, due to their velocities, KKH 6, KK 35, and KK 41 = Cam A are confirmed as members of the Maffei/IC 342 group. Reproductions of spectra of Cam A and KKH 6 are presented in Fig. 3, where a faint H-alpha emission is seen in both the objects.

Further, the blue dwarf compact galaxy KK 78 = UGC 5272b is recognized by us as a companion to another dwarf galaxy, UGC 5272, with a radial velocity difference of only (19 ± 4) km s^{-1}. Together with KKH 54, UGC 5209, and UGC 5186, they probably form a new nearby group of dwarf galaxies, as discussed by Tully et al. (2002).

A more accurate radial velocity of DDO 82, the member of the M 81 group, also should be noted. Its new velocity differs

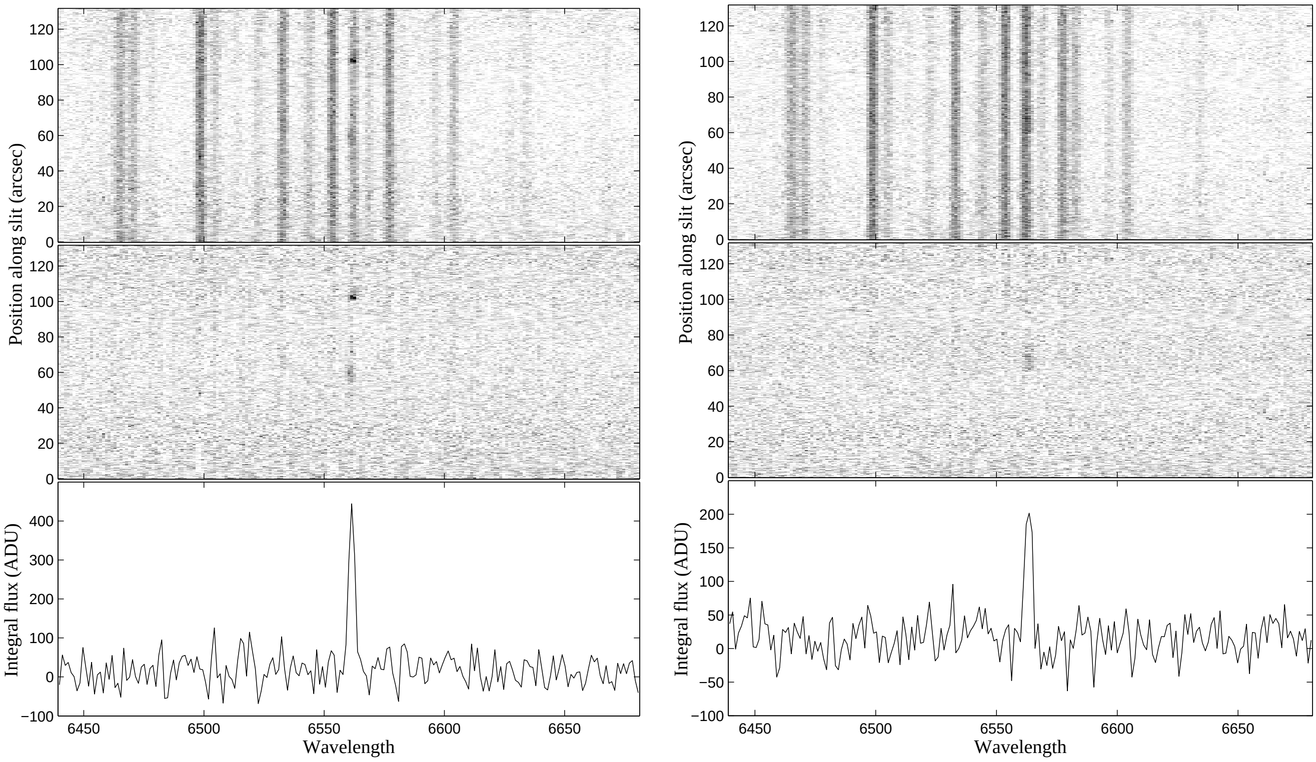

Fig. 3. Reproduction of spectra of two dwarf irregular LSB galaxies in the Maffei/IC 342 group, Cam A and KKH 6, with heliocentric velocities −49 km s^{-1} and +23 km s^{-1}, respectively. Upper panel: rough spectra; middle panel: after sky subtraction; bottom panel: extracted 1D spectra.

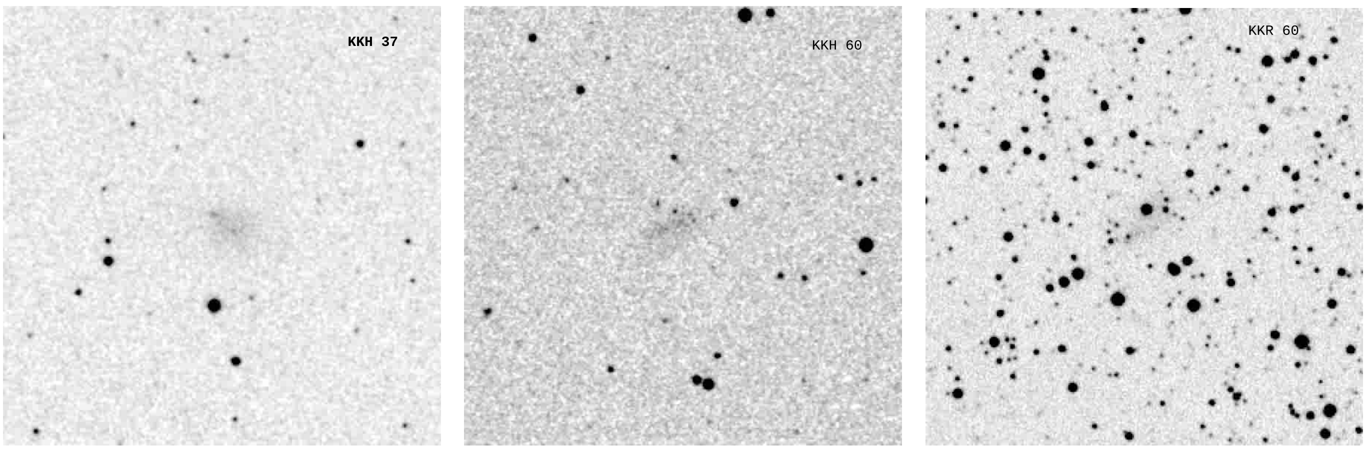

Fig. 4. Red DSS images of three LV galaxy candidates: KKH 37, KKH 60, and KKR 60 with corrected radial velocities, $V_{\rm LG}$, respectively, +214, +104, and +296 km s^{-1}.

from the old velocity in NED by 124 km s^{-1}, decreasing the group velocity dispersion.

New radial velocities of three dwarf members of the NGC 6946 group, KKR 55, KKR 56, and KKR 59, make the velocity dispersion in the group lower (67 km s^{-1} instead of 95 km s^{-1}), which decreases the virial mass-to-luminosity ratio of the group from 56 (Karachentsev et al. 2000) to 28 $M_\odot/L_\odot$.

The three objects KKH 37, KKH 60, and KKR 60 are unclear. Their DSS images are shown in Fig. 4. These objects have radial velocities with respect to the Local Group centroid in the range of [+100, +300] km s^{-1}, and are probable new Local Volume members. However, their possible nearby location should be confirmed with large-scale images.

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