АСТРОФИЗИКА

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STUDY OF NEW SAMPLE OF CANDIDATE BLUE COMPACT DWARF GALAXIES. HI OBSERVATIONS OF 73 OBJECTS AT NANCAY RADIO TELESCOPE

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HI observations are presented for a new sample of 73 candidates BCDGs. HI emission have been detected from 36 and possible from 11 galaxies. For detected galaxies HI radial velocities, HI line width measured at 50% and 20% of the maximum intensity, HI fluxes and HI masses are determined. The distributions of several parameters are given.

1. *Introduction.* Soon after their discovery [1,2] Blue Compact Dwarf Galaxies (BCDGs) begun to focus interest, because (i) They are undergoing intense burst(s) of star formation converting gas into young stars with rates between about 0.1 and few solar mass per year. (ii) They are ideal laboratories for investigation of star formation not propagating by density waves. (iii) They provide attractive cases to study galactic chemical evolution, because their abundance are easy to measure from their ionized gas spectrum and their scalelengths are small. (iv) Some of them, found to be very metal-deficient were look at as fair candidates for "zero-redshift primeval galaxies". Hence they were also prime targets to solve the difficult cosmological problem of the primeval helium abundance value. (v) For BCDGs exist the problem of hidden mass [3]. Total mass of a classic BCDG is much more for its interpretation by simple summing up neutral and ionized gas, young and old stellar masses.

Now is well determined that genuine BCDGs are objects with low metal content and high ratios of HI to total mass, forming stars at prodigious rates, low luminosity and small size mainly with two very high surface brightness and close distributed components in dense common envelope. Nearly all genuine BCDGs were selected from the samples of the objects - candidates for BCDGs with more wide ranges of properties related to their heavy element abundance and HI content, star formation rate luminosity, size and morphological structure (e.g. [4]).

In order to enlarge the sample of genuine BCDGs and to help to understand their nature we have started a multi-wavelength study of the new sample of the candidates of BCDGs. The sample was built on the base of

Byurakan First (FBS), Second (SBS) and also Case Blue, Kiso's, Wasilewsky's, UM surveys. The selection criteria for our sample of about 200 candidates of BCDGs are:

$-M_p > -17^m$ for $H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$. This magnitude limit is close to that defined by Sandage and Bingelli [5] for dwarf galaxies. It may be noted that the fraction of spiral galaxies drops sharply among galaxies less luminous than $M_p = -17^m$ (e.g. [6]).

- Compact structure. Clear absence of spiral arms or a obvious irregular morphology, confirmed by high resolution imagery.

- The existence of very strong, sharp and narrow emission lines.

Since star formation normally requires the presence of high amount of neutral gas, we have carried out a study of HI content of a sample in order to determine the amount of neutral gas present. In Sec.2 we describe the HI observations and data reduction. In Sec.3 data for HI 21 cm detected, possibly detected and not detected candidate BCDGs are presented. In section 4 we are summarized some statistical properties of the observed galaxies.

2. *Observations and data reduction*. The observations were carried out at March 1993 and April 1994 and were made with the meridian-transit Nancay radio telescope, which has a collecting area equal to that of a 94 m. diameter parabolic dish. We used a two-channel, dual polarization 21 cm spectrometer as receiver with a minimal system temperature (at Dec=15deg.) of about 37 K in both polarization. The spectrometer is a 1024 channels autocorrelator with a total bandwidth of 6.4 MHz. It was used in the integration mode and was splitted into two banks of 512 channels each with channel width, corresponding to $2.64\,\mathrm{km\,s^{-1}}$. After boxcare smoothing the final resolution is typically $10\,\mathrm{km\,s^{-1}}$. The two polarizations were detected independently and averaged to improve sensitivity. We take in account that the gain of the antenna in vertical polarization is 75% of the horizontal one, at every declination. The variation of the horizontal gain with declination is calculated according to approximated formulae of Fouque et al [7]. The half-power beam width at 21 cm is 3.6' (EW) x 22' (NS) at zero degree declination.

The observations were made in the standard total-power mode, consisting of cycle of 2 min on-source and 2 min off-source integrations. The position of comparison field was approximately 20' eastward from the source. The number of cycle for one transit was between 8 and 15 but usually 12. The calibration of the telescope was obtained by measuring strong radio sources with accurately known fluxes at different declinations.

Data reduction was done using spectral line reduction package DRAWSPEC developed by H.S. Liszt at NRAO. For each final spectra, which are accumulated averages of difference spectra constructed from individual ON-OFF pairs, after baseline fitting and subtraction, HI profile parameters (the systemic velocity, the line width at the 50% and 20% level of the maximum, the area under the profile) were extracted by fitting of the Gaussians.

3. *Results.* In total, at Nancay radio telescope we detected HI emission from 36 and possibly from 11 from 70 galaxies which are less luminous than - 17.0^m. Table 1 gives the observational results, namely the measured

Table 1

THE HI PARAMETERS OF THE 39 DETECTED AT 21 cm BCDGs.

OBJECTS	RA (1950) DEC (1950)	m_b	V_{hel} dV (kms^{-1})	V_{vir} dV (km s^{-1})	FWHM 50% dFWHM (kms^{-1})	FWHM 20% dFWHM (kms^{-1})	F dF (Jy kms^{-1})	$M(M_\odot)$ dM	Notes
1	2	3	4	5	6	7	8	9	10
KUG 0806+417	08 06 12.0	15.5	704.1	1003.1	87.2	132.8	3.7	1.6E+08	
	41 44 31		0.6	0.6	2.4	3.6	0.1	4.6E+06	
Mrk 1416	09 17 25.7	17.0	2326.5	2563.7	60.5	92.2	1.7	4.8E+08	
	52 46 53		1.1	1.1	1.4	2.2	0.4	1.0E+08	
Mrk 1424	09 42 56.4	16.5	1182.4	1428.7	76.3	116.3	1.4	1.2E+08	
	57 20 55		2.4	2.4	15.1	23.0	0.3	2.3E+07	
SBS 1006+578	10 06 11.9	17.0	1516.6	1681.3	91.0	138.7	1.8	2.2E+08	
	57 48 42		6.0	6.0	7.4	11.3	0.2	2.4E+07	
Wa 8	10 16 16.0	15.2	1083.5	1339.9	42.4	64.7	1.6	1.2E+08	*
	21 32 00		1.3	1.3	12.3	18.8	0.2	1.4E+07	
Mrk 416	10 40 24.0	14.8	1326.8	1636.9	90.8	138.3	1.3	1.4E+08	*
	20 40 53		6.1	6.1	7.2	11.0	0.2	1.9E+07	
SBS 1054+504	10 54 2.5	16.5	1357.8	1478.5	92.2	140.5	1.0	8.8E+07	*
	50 24 19		8.0	8.0	21.0	32.0	0.4	2.8E+07	
Mrk 1445	11 14 42.6	16.5	2863.3	2934.8	127.1	193.7	1.7	6.3E+08	
	51 42 17		8.3	8.3	36.2	55.2	0.6	1.8E+08	
UM 422	11 17 39.0	17.8	1607.0	1828.5	96.6	147.2	13.9	2.0E+09	*
	02 48 16		2.6	2.6	10.4	15.9	1.4	1.8E+08	
CG 103	11 20 26.8	15.6	1616.8	1804.3	91.3	139.2	2.1	2.9E+08	
	30 45 18		3.6	3.6	11.2	17.0	0.2	2.6E+07	
UM 439	11 34 2.0	15.1	1099.1	1573.1	97.6	148.7	5.7	5.9E+08	*
	01 05 38		4.1	4.1	12.1	18.4	0.2	21.E+07	
Mrk 746	11 38 52.5	15.7	1800.6	1985.5	119.7	182.4	5.9	9.9E+08	
	32 37 38		3.0	3.0	9.2	14.1	0.7	9.9E+07	
Wa 25	11 38 53.0	15.4	1839.7	2015.0	70.0	106.6	1.8	3.0E+08	
	32 42 18		5.2	5.2	14.7	22.4	0.4	6.1E+07	
UM 446	11 39 12.0	17.0	1808.3	2296.5	106.6	162.5	1.1	2.4E+08	*
	-01 37 26		4.9	4.9	11.7	17.8	0.4	8.9E+07	
Wa 29	11 40 45.0	15.1	1789.4	1938.4	134.7	205.3	5.1	8.1E+08	*
	31 43 48		5.7	5.7	5.3	8.1	0.3	4.6E+07	
Wa 30	11 40 55.8	16.0	1811.7	1960.6	97.2	148.1	2.3	3.7E+08	
	31 44 12		3.6	3.6	4.8	7.4	0.1	8.2E+06	
UM 461	11 48 59.0	17.0	1038.7	1193.0	53.9	82.1	2.8	1.1E+08	*

Table 1 (continued)

1	2	3	4	5	6	7	8	9	10
	-2 05 40		1.8	1.8	2.2	3.4	0.1	2.4E+06	
Mrk 1308	11 51 38.5	13.8	1145.2	931.0	31.1	47.4	0.6	2.3E+07	•
	00 24 53		0.5	0.5	5.6	8.6	0.3	8.4E+06	
SBS 1154+534	11 54 14.0	14.0	1074.4	1175.5	135.2	206.0	5.3	3.0E+08	•
	53 26 17		5.5	5.5	15.0	22.9	0.9	4.4E+07	
Mrk 1313	12 09 41.0	16.0	2332.4	2848.4	86.0	131.1	1.2	4.1E+08	•
	00 21 01		11.0	11.0	59.6	90.9	0.7	2.0E+08	
Mrk 1315	12 12 46.4	14.3	846.9	1231.5	63.5	96.8	23.3	1.5E+09	•
	20 55 05.0		0.8	0.8	1.3	2.0	0.7	4.0E+07	
Mrk 773	12 30 38.5	14.1	933.2	998.9	77.7	118.4	3.7	1.6E+08	•
	30 22 00		3.8	3.8	4.7	7.1	0.4	1.3E+07	
Mrk 224	12 44 03.6	16.0	906.5	936.5	55.2	84.1	0.6	2.0E+07	
	48 30 33		3.7	3.7	8.7	13.3	0.2	7.4E+06	
Mrk 1338	12 50 43.5	15.5	1069.1	1646.9	67.9	103.4	0.8	9.5E+07	
	25 32 58		16.6	16.6	19.2	29.2	0.3	3.0E+07	
UM 533	12 57 24	15.0	886.5	641.7	48.0	73.1	2.0	3.5E+07	•
	02 19 10		1.1	1.1	12.0	18.3	0.3	4.5E+06	
UM 538	13 00 07.0	18.0	896.0	712.0	51.0	77.7	0.8	1.7E+07	•
	01 20 31		6.0	6.0	9.0	13.6	0.1	2.4E+06	
SBS 1331+493	13 31 20.3	15.0	598.8	638.5	49.0	74.7	5.0	8.5E+07	
	49 21 35		0.4	0.4	0.6	1.0	0.1	6.9E+05	
Mrk 1480	13 40 55.9	16.8	1798.4	1805.6	51.1	77.9	1.3	1.8E+08	•
	52 57 36		1.6	1.6	4.5	6.9	0.1	1.2E+07	
Mrk 1481	13 41 03.5	17.0	1802.8	1810.4	66.8	101.8	1.4	1.9E+08	•
	52 56 22		1.5	1.5	13.8	21.0	0.2	2.1E+07	
SBS 1400+461	41 00 12.3	16.5	2114.9	2076.3	93.0	141.8	1.7	3.0E+08	
	46 05 53		5.3	5.3	32.6	49.7	0.5	7.8E+07	
SBS 1415+437	14 15 03.4	16.0	607.3	673.3	49.8	75.9	4.5	8.5E+07	
	43 43 42		2.0	2.0	3.7	5.6	0.3	4.8E+06	
SBS 1428+457	14 28 19.8	16.0	2360.4	2394.0	121.1	184.6	4.3	1.0E+09	
	45 45 54		7.2	7.2	9.2	14.1	0.6	1.2E+08	
Mrk 1384	14 30 23.5	17.0	2296.6	2558.9	154.8	236.0	4.1	1.1E+09	
	06 13 07		16.3	16.3	35.3	53.9	0.7	1.7E+08	
Mrk 826	14 49 27.7	15.0	722.1	835.1	42.9	65.4	0.6	1.8E+08	
	52 36 44		7.8	7.8	18.4	28.0	0.2	4.7E+07	
SBS 1504+514	15 04 18.3	16.5	3777.6	3857.1	132.9	202.5	3.7	2.3E+09	
	51 26 36		9.9	9.9	13.6	20.7	1.1	5.7E+08	
Mrk 487	15 35 48.4	15.7	663.7	870.8	68.6	104.5	0.8	2.6E+07	•
	55 25 34		9.5	9.5	4.7	7.2	0.2	5.8E+06	
Mrk 13	07 51 56.8	14.4	1371.4	1702.0	168.5	256.8	5.0	6.1E+08	•
	60 26 17		1.4	1.9	4.6	7.0	0.2	1.7E+07	
KUG 0758+615	07 58 12.9	13.6	1606.6	1898.7	151.4	230.7	7.6	1.2E+09	•
	61 31 41		2.1	2.1	11.2	17.1	0.8	1.1E+08	
Haro 22	09 47 17.9	14.3	1443.9	1691.0	66.3	101.0	2.9	3.4E+08	•
	28 14 48		2.7	2.7	3.6	5.5	0.2	1.7E+07	

Notes to Table 1

Listed here are all companions of the galaxies lie in the beam of the radio telescope which are brighter or slightly fainter and/or smaller than the observed galaxies and there is therefore a possibility that the companion has the same redshift and contaminates the spectra. Previously detected at 21cm objects are noted.

Was 8 - Previously was detected at 21cm [9]. Two HII regions in the common envelope.

Mrk416 - Previously was detected at 21cm [9].

SBS1054+504 - Faint galaxy at 9' E, 1.1'N

UM422 - HII region in the bright Irr galaxy UGC 6345. UGC 6345 previously was detected at 21 cm [9] and mapped [10].

UM439 - Previously was detected and mapped at 21 cm [10]. Possibly confused by UGC 6578 at 2' W, 22" N.

Was29 - Previously was detected at 21 cm [9].

UM446 - Was detected and mapped at 21 cm [10].

UM461 - Previously was detected and mapped at 21 cm [10].

Mrk 1308 - Previously was detected and mapped at 21 cm [10].

SBS1154+534 - Previously was detected at 21 cm [9].

Mrk1313 (UM483) - Previously was detected and mapped at 21 cm [10].

Mrk1315 - HII region in the bright galaxy NGC4204 which is contaminate the spectra by its radiation. NGC4204 - Previously was detected at 21 cm [9].

Mrk773 - Previously was detected at 21 cm [9].

UM533 - Previously was detected and mapped at 21 cm [10].

UM538 - Previously was detected and mapped at 21 cm [10].

Mrk1480 - Possibly confused by Mrk1481 at 7' E, 74" S.

Mrk1481 - Possibly confused by Mrk1480 at 7' W, 74" N

SBS1400+461 - Two HII regions in the common envelope.

Mrk487 - Previously was detected at 21 cm [9].

Mrk13 - Previously was detected at 21 cm [9].

KUG0758+615 - Previously was detected at 21 cm [9].

Haro22 - Previously was detected at 21 cm [9].

HI parameters of the 36 detected candidate BCDGs. In the end of the Table 1 separately are presented data for three other detected galaxies which are more luminous than -17.0^m. A description of the columns of Table 1 follows:

Column 1 – Candidate BCDG name; Column 2 – The 1950.0 coordinates of the galaxy; Column 3 – Apparent blue magnitude. Average uncertainty is in the order of 0.5^m; Column 4 – HI heliocentric radial velocity; Column 5 – HI radial velocity derived from observed HI heliocentric velocity through a spherical Virgo flow model according the formalism of [8]; Column 6 and 7 – HI line width. They are measured at 50% and 20% of maximum intensity; Column 8 – Area under the HI profile in units of Jy km s^{-1}; Column 9 – The HI mass in solar units. HI radial velocity from column 5 was used.

A Hubble constant of 75 km s^{-1} Mpc^{-1} is adopted; Column 10 – Galaxies with an asterisk in this column have a note at the end of the Table.

The smoothed 21 cm HI spectra are given at the end of the article.

Table 2 gives observational results of the candidate BCDGs with possibly

Table 2

THE HI PARAMETERS OF THE 11 POSSIBLY DETECTED AT 21 cm BCDGs.

OBJECTS	RA (1950) DEC (1950)	m_b	V_{hel} (kms^{-1})	V_{vir} (km s^{-1})	FWHM 50% (kms^{-1})	FWHM 20% (kms^{-1})	F (Jy km^{-1})	$M(M_\odot)$	Notes
CG 10	09 09 50.2 31 53 12	17.0	1409	2118	28	42	0.3	4.8E+07	
Mrk 1426	09 46 03.1 48 47 51	16.5	1840	2037	18	27	0.3	5.2E+07	
Mrk 22	09 46 03.1 55 48 46	16.0	1583	1771	44	66	0.3	4.5E+07	*
CG 72	10 49 36.4 32 54 30	16.0	1541	1786	167	255	2.0	2.7E+08	
Mrk 1271	10 53 33.3 06 26 24	15.7	1036	1418	28	42	0.4	3.2E+07	
Mrk 1450	11 35 51.3 58 09 24	16.0	969	1088	60	91	0.3	1.3E+07	
UM 452	11 44 26.0 -00 00 57	14.9	1398	1996	60	91	0.6	9.6E+07	*
SBS 1144+591	11 44 21.9 59 09 50	16.5	2860	2910	84	128	0.6	2.1E+08	
UM 491	12 17 18.0 02 03 02	15.8	2001	2594	62	94	0.9	2.4E+08	*
Mrk 1335	12 44 28.4 26 50 14	15.5	834	1179	114	174	1.3	7.4E+07	
SBS 1423+518	14 23 41.1 51 46 36	18.0	1978	2051	83	126	0.4	7.5E+07	

Notes

Mrk22 - Previously was detected at 21cm [9].

UM452 - Previously was detected at 21 cm [10].

UM491- Previously was detected at 21 cm [10].

detected HI emissions. The description of columns of the Table 2 is the same as of the Table 1. To prove existence of HI emission from these objects we need more sensitive HI observations.

Table 3 gathers all the negative results of HI observations of candidate BCDGs at Nancay radio telescope. The description of columns of Table 3

Table 3

NOT DETECTED AT HI 21 cm BCDGs.

OBJECT	RA (1950)	DEC (1950)	V_{opt} (km s^{-1})	m_b
KUG 0814+251	08 14 21.5	25 07 06	1890	17.0
KUG 0919+545	09 19 43.1	54 30 26	3450	16.5
KUG 0929+324	09 29 01.8	32 27 00	1500	16.5
Mrk 1423	09 39 24.0	59 12 10	1710	17.0
SBS 0940+544	09 40 52.0	54 25 13	1710	17.0
SBS 0943+543	09 43 40.7	54 19 33	1620	16.0
CG 50	10 03 27.0	29 11 24	1315	15.0
Mrk 1434	10 30 56.3	58 19 20	2250	16.5
Mrk 724	10 38 26.9	21 37 25	1020	16.5
CG 76	10 54 02.9	31 21 36	1630	16.0
SBS 1123+576	11 23 23.1	57 37 43	420	16.5
Mrk 1446	11 24 45.5	54 11 26	2880	16.5
WAS 23	11 32 48.0	33 34 50	1590	15.2
CG 113	11 33 24.1	32 39 55	2685	16.0
SBS 1147+520	11 47 16.4	52 00 51	1080	16.5
Mrk 1460	11 48 12.8	48 31 46	780	17.0
Mrk 641	11 49 52.2	35 10 23	2160	16.5
SBS 1205+557	12 05 57.6	55 42 07	1860	15.5
SBS 1401+490	14 01 50.4	49 00 12	870	16.0
Mrk 475	14 37 03.0	37 01 07	539	17.0
Mrk 850	15 20 12.5	31 39 11	2310	16.5
Mrk 1499	16 34 07.9	52 18 57	2880	15.6
SBS 1723+565	17 23 41.0	56 31 22	3149	17.0

follows:

Column 1 - Candidate BCDG name; Column 2 and 3 - The 1950.0 coordinates of the galaxy; Column 4 - The optical heliocentric radial velocity; Column 5 - Apparent blue magnitude. Average uncertainty is in the order of 0.5^m.

4. *Statistical properties of the sample*. In Fig.1 and 2 we present the histograms of the apparent blue magnitudes and heliocentric radial velocities for detected, possibly detected and not detected BCDGs. For detected BCDGs the distribution of the HI lines FWHMs at 50% are presented in Fig.3. The distribution of HI masses in solar units are shown in Fig.4.

The comparison of the apparent blue magnitudes distributions for HI detected and not detected BCDGs (Fig.1) shows that detected galaxies are brighter than not detected ones. The difference between their average values is significant at the level of 94%. The difference between the distributions of radial velocities for detected and not detected galaxies (Fig.2) was found to be significant at a level of only 87%.

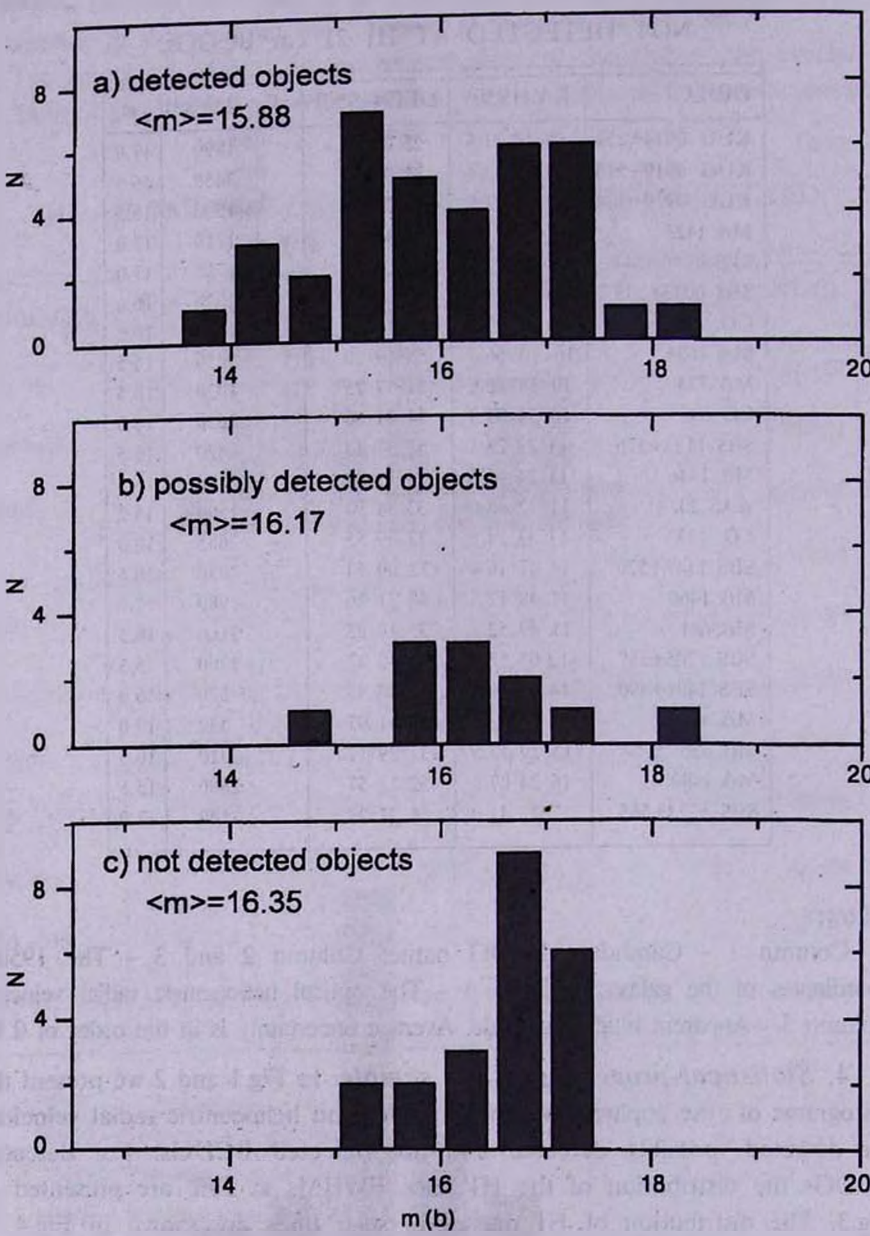

Fig.1. The distributions of the apparent blue magnitudes.

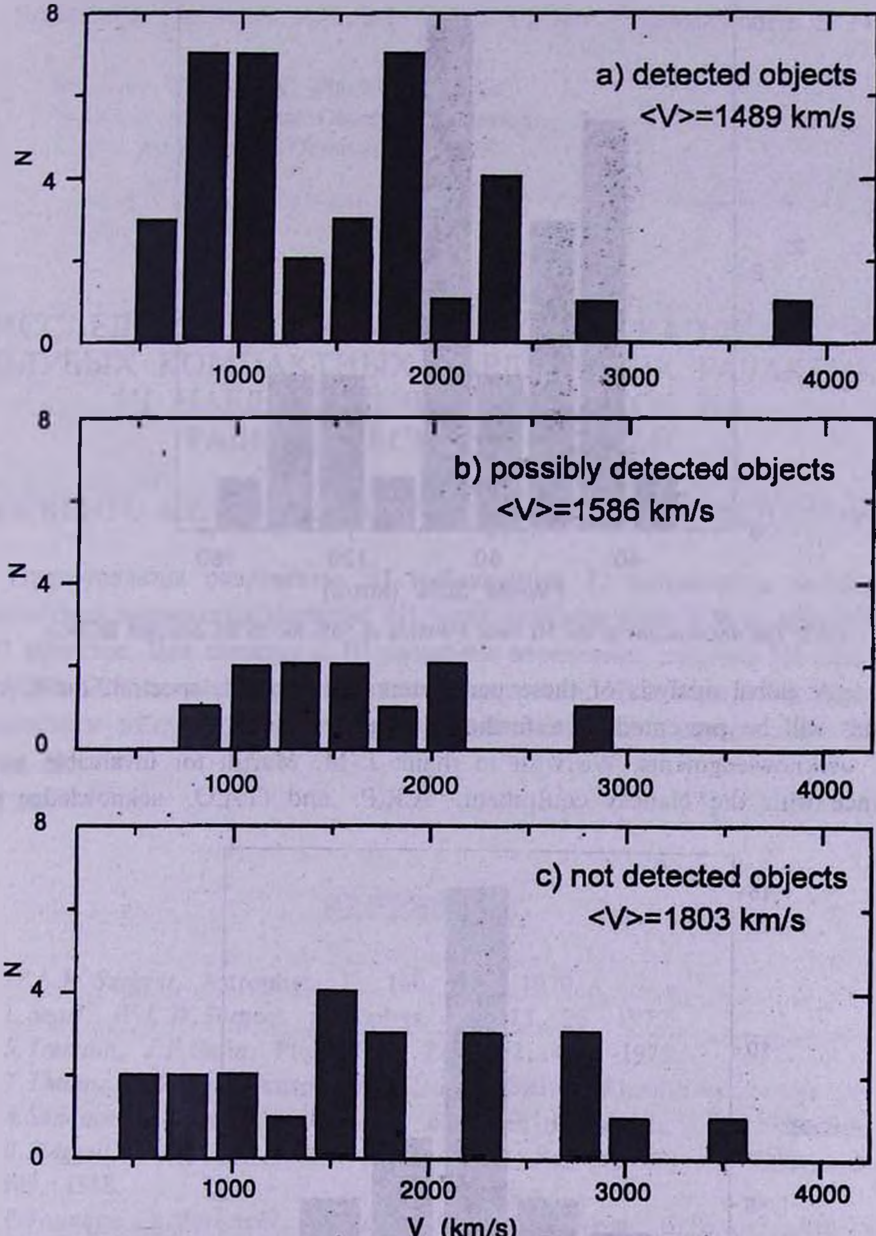

Fig.2. The distributions of the heliocentric radial velocities.

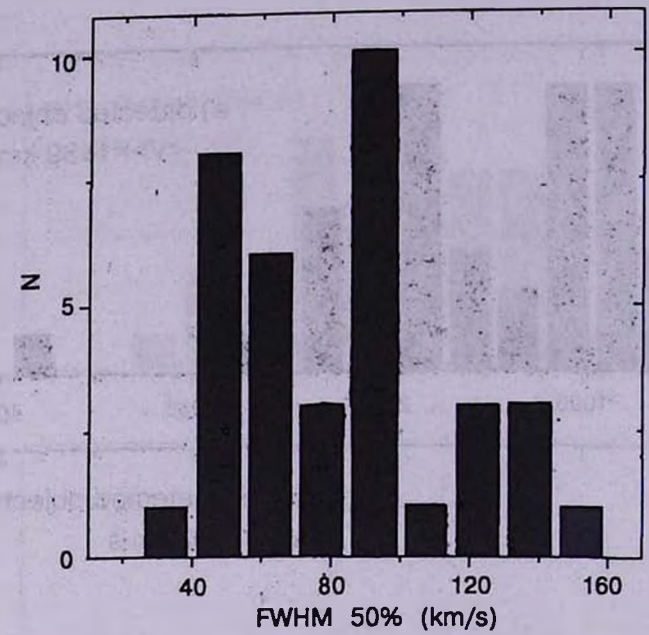

Fig.3. The distributions of the HI lines FWHMs at 50% for 36 HI detected BCDGs.

A global analysis of these parameters with optical, spectral, radio, etc. ones will be presented in a forthcoming papers.

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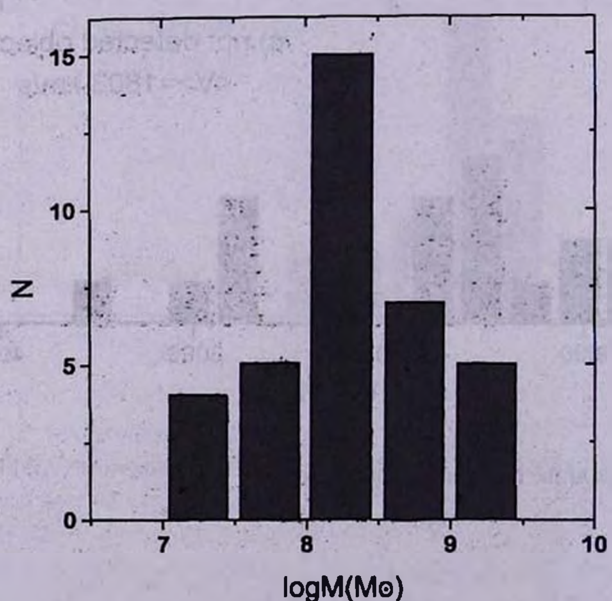

Fig.4. The distributions of the HI masses in solar units for 36 HI detected BCDGs.

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ИССЛЕДОВАНИЕ НОВОЙ ВЫБОРКИ КАНДИДАТОВ ГОЛУБЫХ КОМПАКТНЫХ КАРЛИКОВЫХ ГАЛАКТИК. HI НАБЛЮДЕНИЯ 73 ОБЪЕКТОВ НА РАДИОТЕЛЕСКОПЕ НАНСЕЙ

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Представлены результаты HI наблюдений 73 кандидатов голубых компактных карликовых галактик. HI эмиссия обнаружена у 36 и, вероятно, у 11 объектов. Для галактик с HI эмиссией определены ширины HI линии на 50% и 20% от максимума интенсивности линии, HI потоки и HI массы. Приводится распределение некоторых параметров этих галактик.

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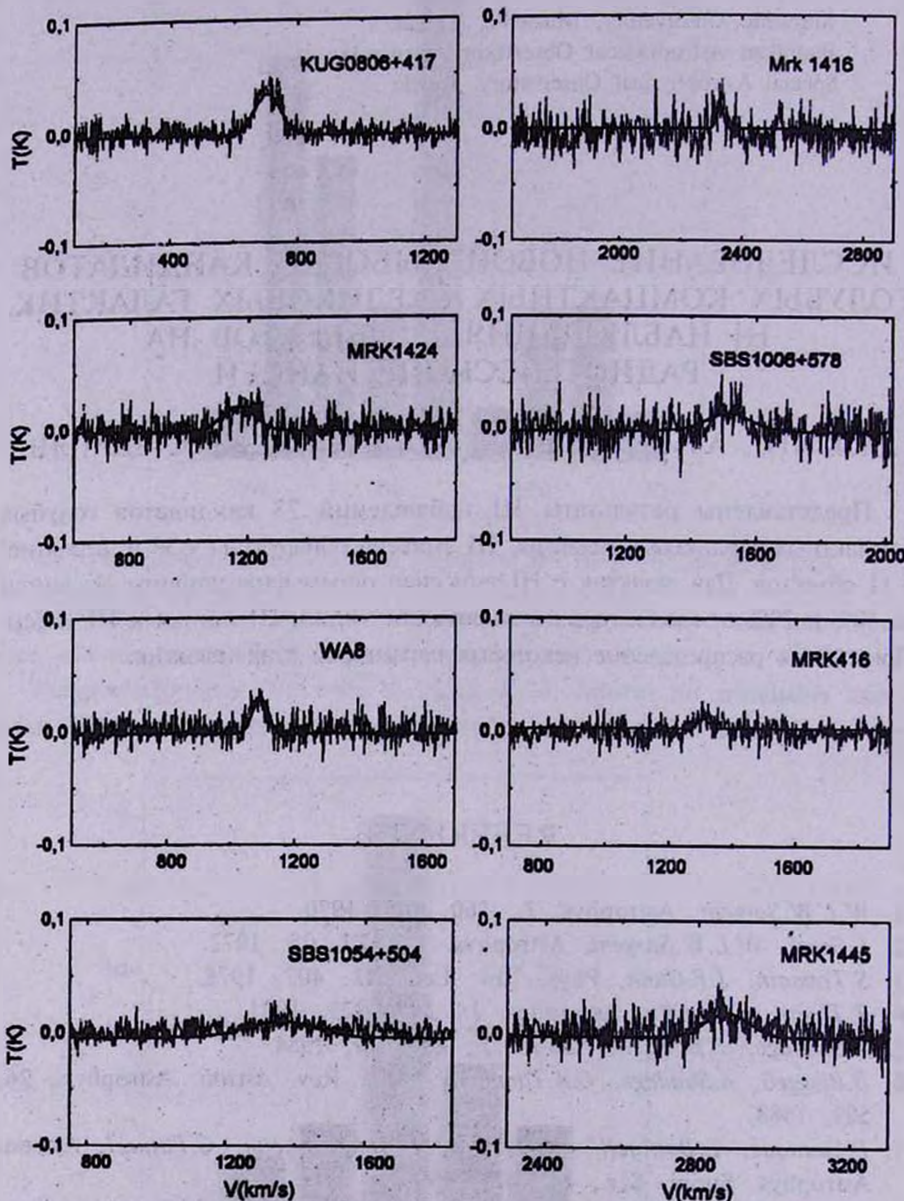
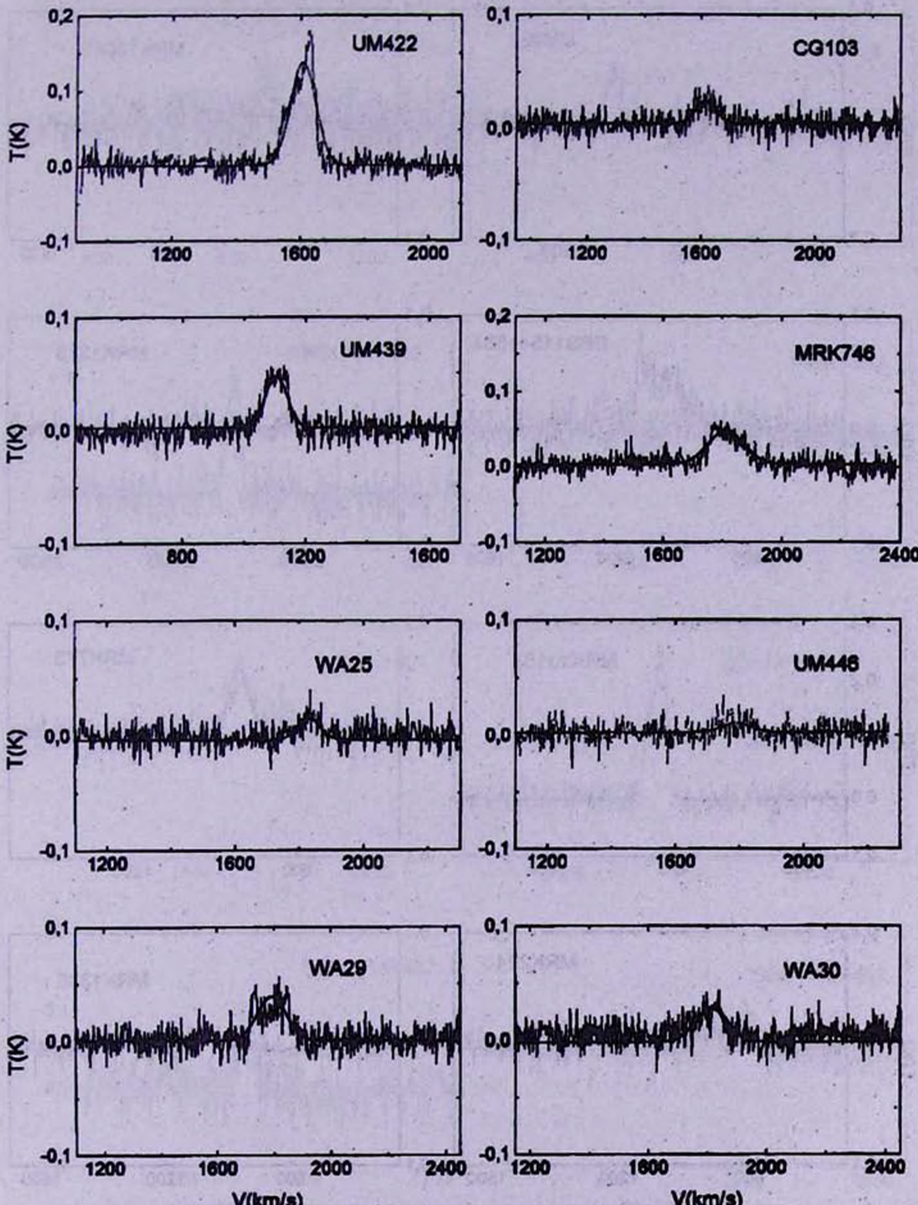
THE SMOOTHED 21 sm HI SPECTRA OF 36 BCDGS

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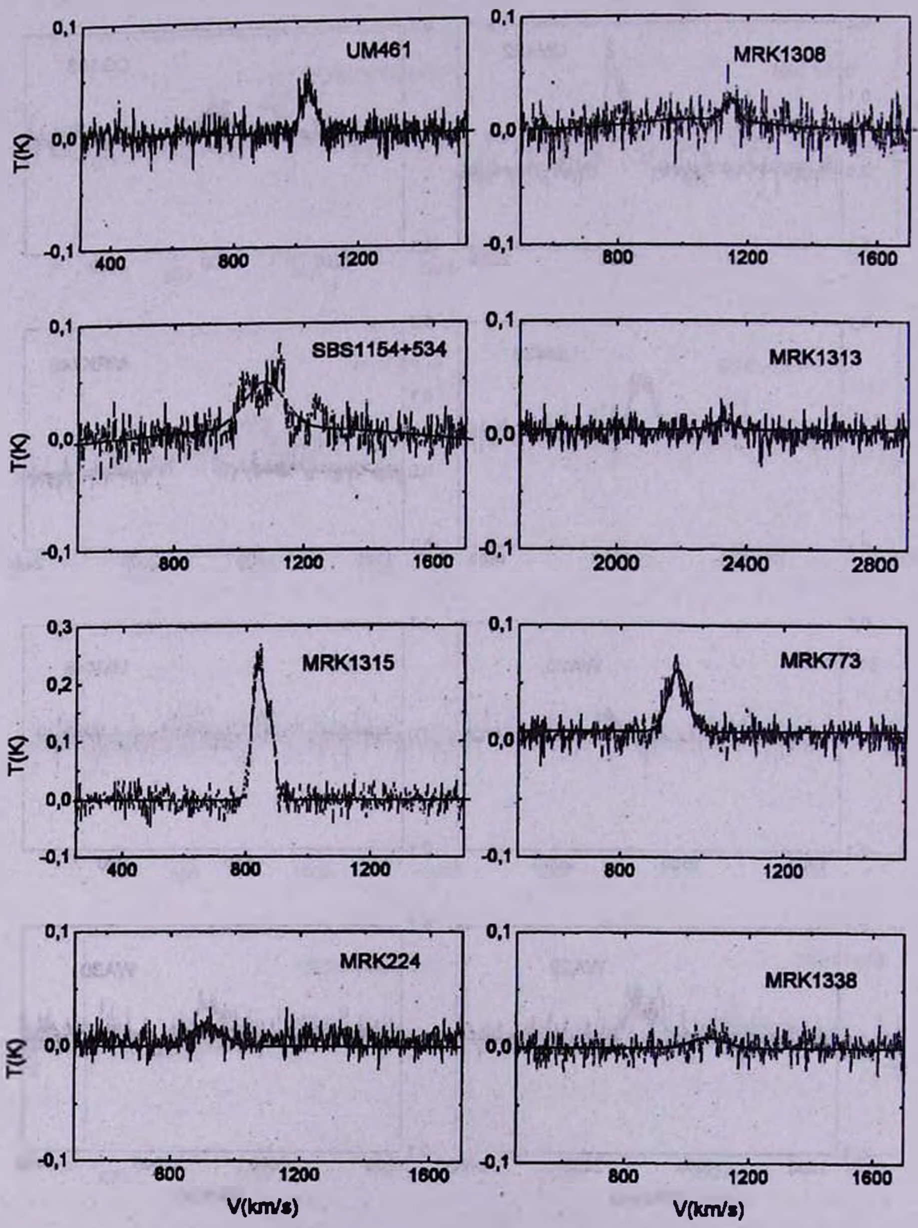
V(km/s)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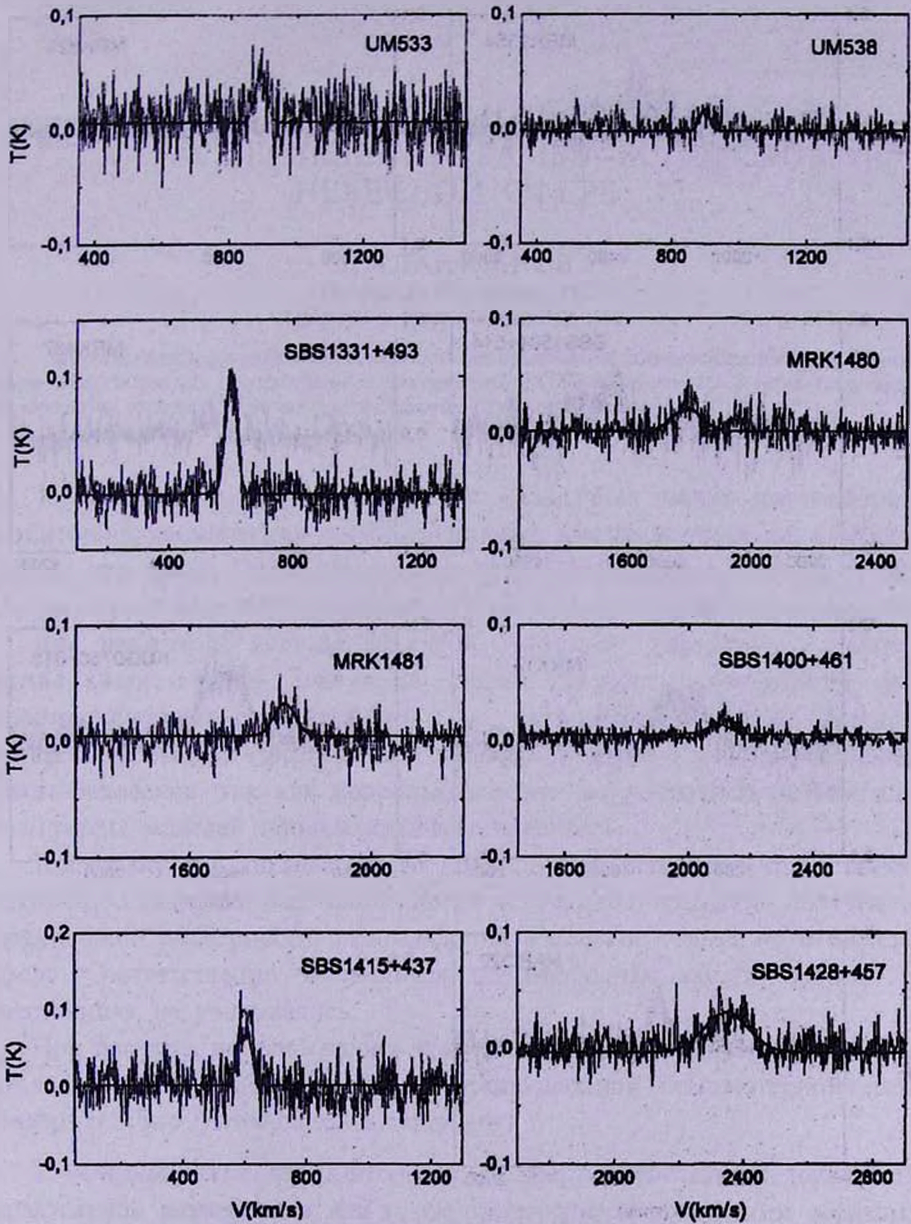
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SBS1400+461
SBS1415+437
SBS1428+457
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V(km/s)
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0,0
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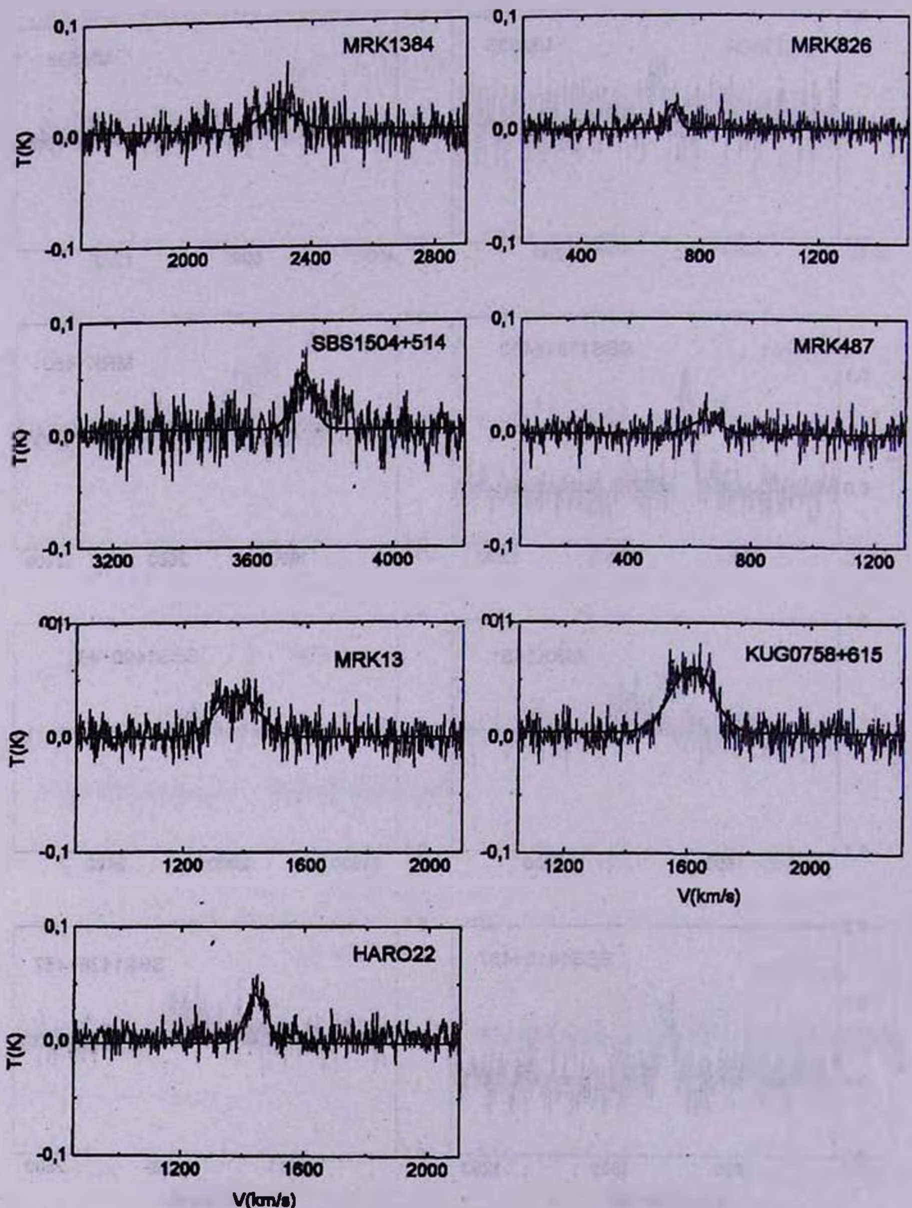
0,2
400
800
1200
1600
2000
2400
2800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KUG0758+615
HARO22
T(K)
V(km/s)