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New nearby very metal-deficient blue compact galaxies

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Abstract. Two new blue compact (or HII) galaxies HS 1013+3809 and HS 1442+4250 were discovered in the course of the Hamburg/SAO survey for emission-line galaxies. Both of these very metal-deficient galaxies (log(O/H)+12.0 = 7.58 for HS 1013+3809 and 7.68 for HS 1442+4250) are comparatively bright and nearby, and thus are good laboratories for detailed study of star formation bursts and related processes in very low-metallicity environment.

Key words: galaxies: abundances – galaxies: compact blue – galaxies: spectroscopy

1. Introduction

Since their first spectroscopy study (Searle & Sargent, 1972) blue compact galaxies (hereafter BCGs) were classified as evolutionary young systems due to the fact that their metal content is many times lower than that of large galaxies. I Zw 18 as a BCG with exceptionally low metallicity ($Z = 1/56\ Z_\odot$) was even suggested as a candidate for local true young galaxy forming its first stellar generation. In fact, most of several hundred BCGs with measured abundance of heavy elements have Z in the range from 1/10 to 1/3 of $Z_\odot$. Only a few percent of them have metallicities lower than 1/15 $Z_\odot$ (or 12+log(O/H) < 7.74). However precisely such galaxies are the most interesting from the point of view of studying early chemical evolution of galaxies. Moreover, as demonstrated recently by Izotov and Thuan (1999), exactly BCGs with Z lower than 1/20 $Z_\odot$ are the best candidates for local young galaxies.

For the past few years our research group has been concerned with the search for and study of such extremely low-metallicity galaxies. In the frame of this project such interesting objects as SBS 0335–052 (Izotov et al., 1990), 0335–052W (Pustilnik et al., 1997, Lipovetsky et al., 1999) and HS 0822+3542 (Kniazev et al., 1999) with Z in the range 1/50 to 1/36 of $Z_\odot$, that is, the most metal-deficient galaxies after I Zw 18 have been discovered. Here we report on the discovery of two new very low-metallicity BCGs found in the frame of the on-going project, *The Hamburg/SAO Survey for Emission-Line Galaxies* (HSS) (Ugryumov et al., 1999, Pustilnik et al., 1999). These are nearby and comparatively bright galaxies, which makes them very suitable for detailed studies.

Table 1: *Some observational and derived parameters of new metal-poor BCGs*

Value	1013+3809	1442+4250
Right ascension (1950.0)	$10^h13^m27.6^s$	$14^h42^m17.9^s$
Declination (1950.0)	+38°09′43″	+42°50′13″
Velocity(hel)(km sec^{-1})	1198±6	780±42
Distance (Mpc)	20.7	13.1
B-mag	16.5†	16.0‡
M_B	−15.1	−14.6
12+log(O/H)	7.58±0.04	7.68±0.04
Angular size (″)	12×12†	60×12‡
Linear size (kpc)	1.3×1.3	4.2×0.9

† KUG data; ‡ UGC data.

2. Observations and reduction

The blue compact galaxies HS 1013+3809 (KUG 1013+381) and HS 1442+4250 (UGC 9497) were selected as candidates for emission-line galaxies on the Hamburg Quasar Survey objective prism photoplates (Hagen et al., 1995). The galaxy HS 1442+4250 had already been known from Popescu et al. (1996) as an emission-line galaxy (ELG), but no classification and details of spectra had been presented. For the galaxy HS 1013+3809 there were no spectral information in literature. Short exposure time follow-up spectroscopy of these objects at the 6 m telescope of SAO RAS on April 4 and 6, 1998 showed quite a strong emission line of [OIII] λ4363Å, which pointed to high temperature T_e and possible low metallicity. Their higher S/N spectra were obtained on April 4, 5 and 6, 1998.

The spectrograph SP-124 at the Nasmyth-1 focus of the 6 m telescope with the Schmidt-Cassegrain camera and Photometrix CCD PM1024 ($24 \times 24\,\mu$m

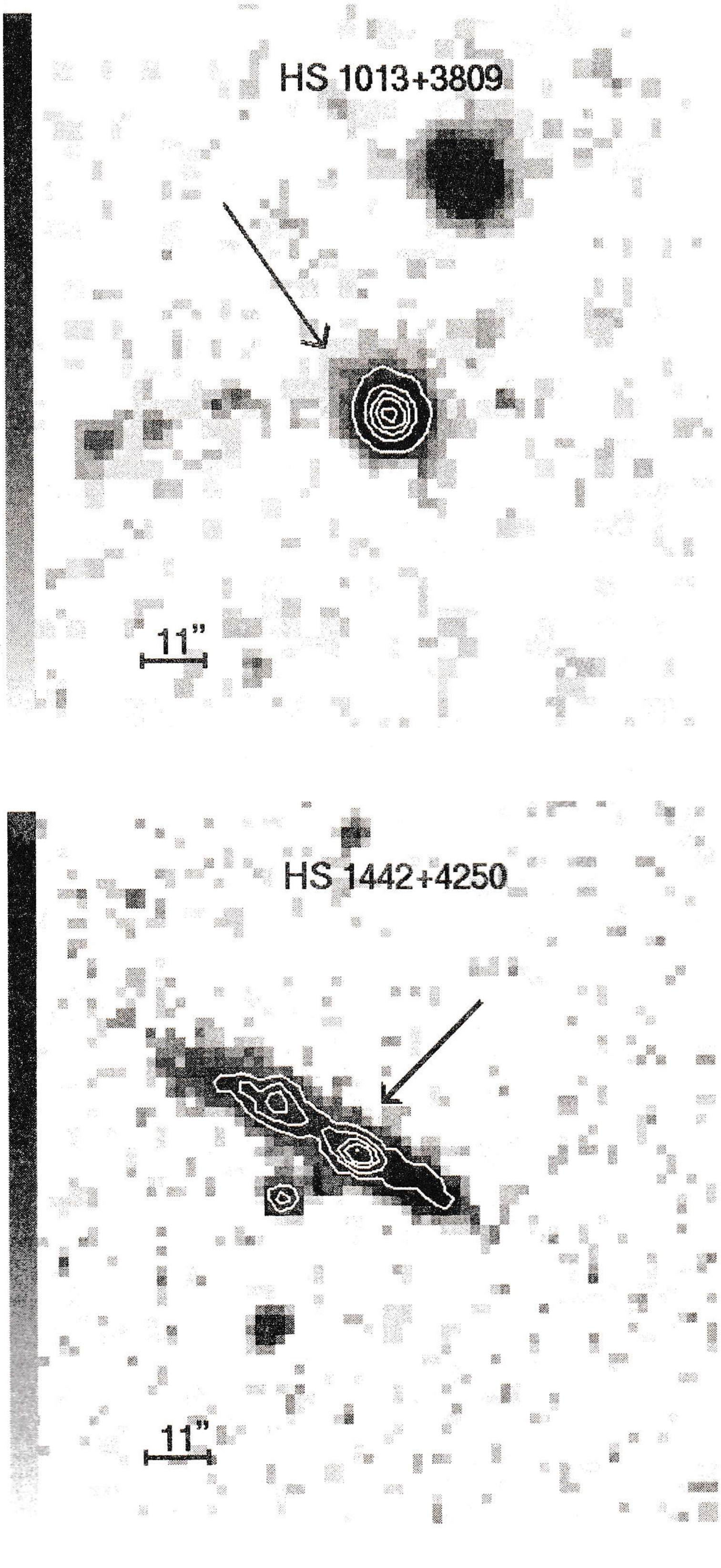

Figure 1: *DSS-2 images of galaxies HS 1013+3809 (upper) and HS 1442+4250 (lower). The north is up, east is left. Isophotes in white show the morphology of the brightest parts.*

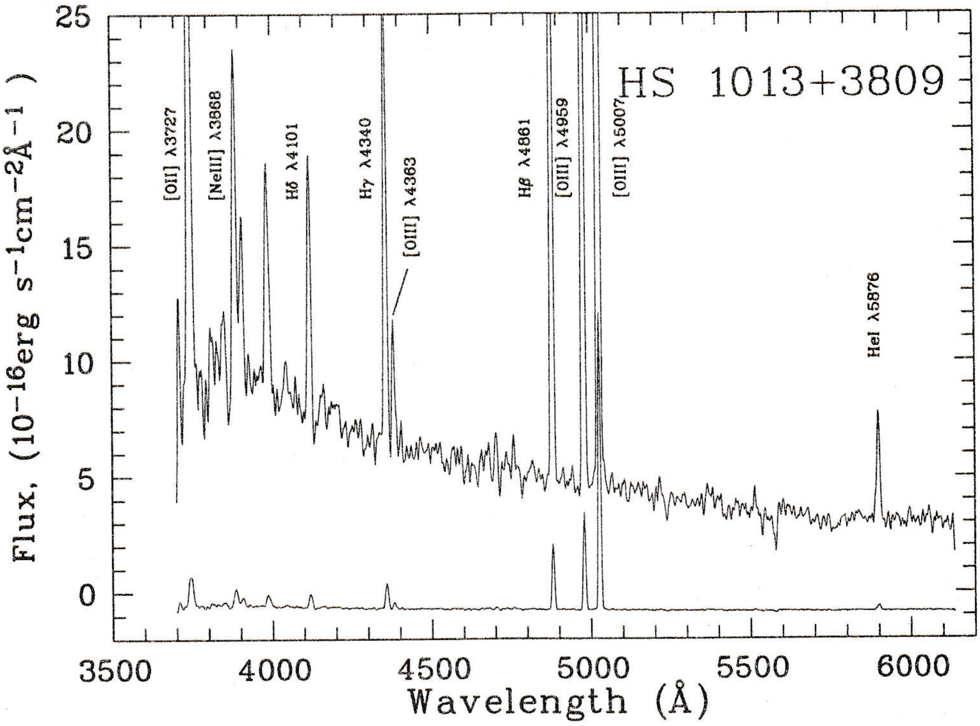

Figure 2: *Spectrum of galaxy HS 1013+3809. The same spectrum at the bottom scaled 1/20 is to show the ratios of strong lines.*

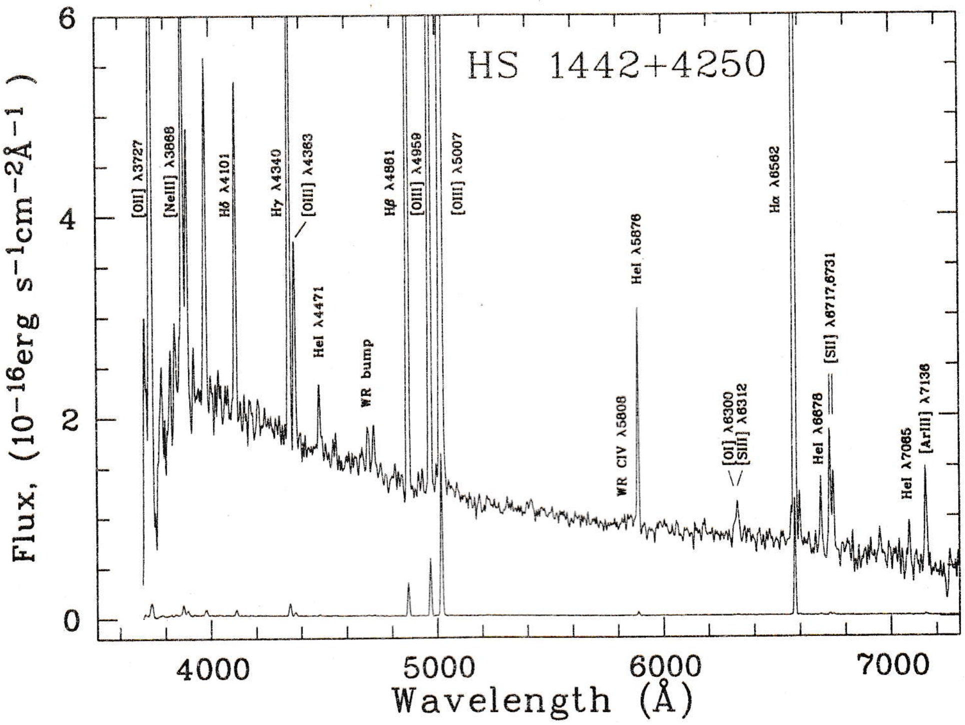

Figure 3: *Spectrum of galaxy HS 1442+4250. The same spectrum at the bottom scaled 1/60 is to show the ratios of strong lines.*

Table 2: *Relative intensities of emission lines in the spectra of HS 1013+3809 and HS 1442+4250 and some derived parameters*

	Galaxy			
	1013+3809		1442+4250	
Ion	$F(\lambda)/F(H\beta)$	$I(\lambda)/I(H\beta)$	$F(\lambda)/F(H\beta)$	$I(\lambda)/I(H\beta)$
3727 [O II]	0.830 ±0.050	0.911 ±0.055	0.649 ±0.033	0.663 ±0.035
4101 Hδ	0.270 ±0.013	0.296 ±0.021	0.191 ±0.005	0.253 ±0.009
4340 Hγ	0.449 ±0.012	0.474 ±0.017	0.425 ±0.010	0.472 ±0.013
4363 [O III]	0.114 ±0.010	0.118 ±0.010	0.123 ±0.009	0.121 ±0.009
4861 Hβ	1.000 ±0.012	1.000 ±0.012	1.000 ±0.011	1.000 ±0.012
4959 [O III]	1.416 ±0.016	1.398 ±0.016	1.734 ±0.021	1.661 ±0.021
5007 [O III]	4.303 ±0.045	4.233 ±0.045	5.076 ±0.045	4.852 ±0.045
6563 Hα	...	...	3.053 ±0.028	2.772 ±0.029
T_e	18000±868		16876±665	
C(Hβ) dex	0.14 ±0.02		0.09 ±0.01	
$F(H\beta)(\times10^{16})$ erg $s^{-1}cm^{-2}Å^{-1}$	544		186	
EW(Hβ) Å	117 ±1.0		144.6 ±1.2	
EW(abs) Å	0.65 ±0.98		5.65 ±0.48	
z (obs)	0.00407±0.00003		0.00260±0.00014	

pixel size) were used in the observations. The spatial scale along the slit was equal to 0.″4/pixel, the slit length was about 40″, and the slit width of 2″ was used. A grating with 600 grooves/mm was employed, resulting in a spectral resolution of approximately 7 Å (FWHM). Long-slit spectra in the ranges 3700–6100 Å (for HS 1013+3809 and HS 1442+4250) and 5000-7400 Å (HS 1442+4250) were obtained. The total exposure time for HS 1013+3809 was broken up into 2×600 s. For HS 1442+4250, the total exposure time was broken up into 3×600 s in blue, and 2×420 s in red. The seeing was 2.″2 during the observations.

The spectra were centered on the brightest central knot of HS 1013+3809 and SW knot in the elongated body of HS 1442+4250 (see DSS images of both galaxies in Figure 1). Series of bias images were obtained twice — at the beginning and at the end of every night. Dark current and flat field were accumulated at the end of each night. Two standard stars from the list of spectrophotometric standards (Massey & Strobel, 1988) (mostly Feige 34 and HZ 44) were observed on every night. A He-Ne-Ar lamp was used for wavelength calibration.

All observations were conducted under the software package `NICE` in MIDAS, described by Kniazev & Shergin (1995).

The raw spectroscopic data were reduced using the contexts `CCDRED` and `LONG` from the MIDAS software package. The reduction of the original two-dimensional CCD data included the standard steps such as: bias and dark subtraction, flat-fielding, cosmic-ray removal. After wavelength mapping subsequent night sky background subtraction was performed. Then the correction for atmospheric extinction and flux calibration was applied. For the flux calibration we used the mean response curve obtained from the observations of standard stars. 1-D spectra were extracted by adding several consecutive CCD rows centered on the object intensity peak along the slit.

3. Results and Discussion

In Figures 2 and 3 we show the 6 m telescope spectra of the blue compact galaxies HS 1013+3809 and HS 1442+4250, in which narrow emission lines typical for high excitation HII-regions are seen. These are Hβ λ4861, [OIII] λλ4959, 5007 and λ4363, several lines of HeI, [NeIII] and [ArIV] for both spectra and Hα λ6562, [NII] λλ6548, 6584 and [SII] λλ6716, 6731 ÅÅ for red part of HS 1442+4250. A more detailed analysis of these spectra in conjunction with other observational data will be presented in a later paper. Here we use only the observed intensities of important hydrogen and oxygen lines to derive the oxygen abundance in both BCGs. They are presented in Table 2, as well as those corrected for extinction and underlying Balmer absorptions (Izotov et al., 1997a). All intensities of the lines are given relative to Hβ, along with the equivalent width of Hβ line EW(Hβ), the observed Hβ flux F(Hβ), the extinction coefficient C(Hβ) and observed redshift. To derive T_e in the regions of OIII and OII and the oxygen abundance, we followed the algorithms also described in Izotov et al. (1997a). To estimate electron density N_e(SII) in HS 1442+4250, the intensity ratio of [SII] lines λλ6716 and 6731 ÅÅ was used as usual. Since the observed ratio F(λ6716)/F(λ6731) > 1.4, the value $N_e = 10\,\mathrm{cm}^{-3}$ was used (Aller, 1984) for this object. For HS 1013+3809 the value $N_e = 10\,\mathrm{cm}^{-3}$ typical of BCGs was adopted as well.

The BCGs' absolute blue magnitudes presented in Table 1 are calculated from the apparent B-magnitudes of the KUG and UGC catalogs and measured heliocentric velocities. The Galaxy extinction correction is not applied since it is very small in comparison with apparent magnitude uncertainties. To make a better accuracy estimate of distances for galaxies which are as close to us, one has to take into account the Virgo flow correction and the motion with respect to the Local group (e.g. Kraan-Korteweg, 1986). This correction was calculated for HS 1013+3809 (ΔV = 354 km s^{-1}) and for HS 1442+4250 (ΔV = 202 km s^{-1}). The Hubble constant was adopted as 75 km s^{-1} Mpc^{-1}.

Well-known Wolf-Rayet features are seen in the spectrum of HS 1442+4250, which makes it interesting for study of evolution of massive stars in this galaxy on a time-scale of a few Myr (Izotov et al., 1997b).

The morphology of these two galaxies is very different. While HS 1013+3809 looks very symmetric and very compact, with intense star formation burst taking place in its very center, HS 1442+4250 is well elongated, resembling an edge-on disk. Strong star formation burst in the SW knot is well outside the center of symmetry of this elongated configuration. Another fainter knot on the opposite side of this "disk" is well seen on DSS image, but its spectrum has not yet been obtained. The different morphology and the relative positions of star formation regions suggest that possible mechanisms of bursting star formation in gas-rich low-mass galaxies may be different.

4. Conclusions

Summarizing the description above, we draw the following conclusions:

1. Two new blue compact galaxies, HS 1013+3809 and HS 1442+4250, discovered in the course of the Hamburg/SAO survey for emission-line galaxies, are very metal-poor objects, with log(O/H)+12.0 = 7.58 and 7.68, respectively.

2. These new galaxies are comparatively bright and nearby and therefore are good laboratories for detailed study of star formation, chemical evolution and interaction of massive stars with ISM in the most low-metallicity dwarf galaxies.

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