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# SPECTROSCOPIC STUDY OF A LARGE SAMPLE OF GALAXIES DISCOVERED IN THE SECOND BYURAKAN SURVEY FIELDS

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The Second Byurakan Survey (SBS) is a well known combined survey, which uses the presence of UV-excess radiation in the continuum, or the presence of emission-lines in the spectra for the identification of active and star-forming galaxies. This paper reports on a comparative study of 77 galaxies identified with UV-excess, and 34 galaxies identified via emission-line techniques in the fields of the SBS. The spectroscopic parameters used for the comparison are the [OII] λ3727/Hβ and [OIII] λ5007/Hβ emission-lines ratios, the equivalent widths of [OII] λ3727 , [OIII] λ5007 and Hβ emission-lines, and the $C_{[OIII]} - C_{H\beta}$ index. Spectroscopic parameters as well as new redshifts were determined from the spectra obtained with the 6m telescope of the Special Astrophysical Observatory (Russia). The main results are: 1) Galaxies discovered via UV-excess technique are preferably more active. 2) Galaxies discovered via emission-line technique are preferably high-excitation low-luminosity star-forming galaxies. 3) UV-excess galaxies with faintest UV-excess radiation are likely candidates to be LINER or Sy2 type objects.

Key words: *galaxies - UV-excess galaxies:emission - line galaxies:statistics*

1. *Introduction.* Last four decades particular interest has been devoted to the search for extragalactic blue emission-line galaxies. Many surveys have already isolated galaxies with emission-lines and blue colors. During the course of such surveys active galactic nuclei (AGN) and QSOs are occasionally found, but a large fraction of these newly discovered objects refer to galaxies with strong star formation bursts. Such blue starburst galaxies are rather common as they represent about 10% of all galaxies in the absolute magnitude range $-22.5 \le M(B) \le -16.5$.

Among blue emission-line galaxies, particular attention has been devoted to the subclass of low luminosity galaxies, so-called Blue Compact Dwarf Galaxies (BCDGs), with small size, high surface brightness, are gas-rich and metal-poor and in which star formation takes place in sporadic bursts. BCDGs have been used as prime targets for measuring the primordial helium abundance from their ionized gas (e.g. [1]), chemical (e.g. [2]). They also concur to the understanding of massive stellar evolution (e.g. [3]) and the triggering mechanisms for star formation processes (e.g. [4,5]) and even some clues on the nature of dark matter (e.g. [6]). Taking in account the importance to have large sample of very metal-poor BCDGs, Kunth and Sargent [7] gave a description on how they should appear on objective-prism surveys. BCDGs, during the recent surveys, have been selected from the very presence of strong and narrow emission-lines, featureless and weak but UV-excess continua [8-10]. In spite of their high astrophysical importance, the number of classical BCDGs and their candidates is still limited to a few hundreds.

In the local universe, the majority of narrow emission-line galaxies are called HII [11,12] or starburst galaxies [13] which otherwise are normal galaxies with respect to their morphology. They share the property of forming stars at a high rate at the present epoch. The blue color and UV radiation, in excess of the reddish background of evolved giant star population, originates from a large population of newborn massive OB stars. The hard UV radiation emitted by O stars ionizes the interstellar gas and produces an emission-line spectrum. Detailed investigations of these objects give not only the clues to understand the nature of present-day star formation processes but also offer the opportunity of studying processes of star and galaxy formation and evolution at a substantial cosmological look-back time [14,15]. They help to tackle problems related to the large-scale structure of the Universe (e.g. [16]).

Since the pioneering studies by Haro [17], Zwicky [18] and Markarian [19], many surveys have been devoted to search for such galaxies. The color survey, which proceeds by searching for blue or UV-excess objects, has the advantage to select star-forming galaxies at many stages of their evolution and regardless of the metal content of the gas. Emission-line surveys are limited by seeing effects and guiding and by the limited range of redshift that photographic plates permit to explore with good efficiency. A few surveys have combined both selection criteria in order to improve the detection of objects at all possible stage of evolution. The Case [20] and Second Byurakan (SBS, [21]) as well as the Marseille [22] surveys have shown that the efficiency of finding star-forming galaxies is indeed much larger when UV-excess and line emission are looked for across the same field.

Comte et al. [23] have shown that color surveys (e.g. [24]) sample different galaxies population as compared to low-dispersion prism-objective emission-line surveys (Salzer et al. [25]). Emission-line selected samples (e.g. [25]) span a broader range of colors than purely UV-excess objects [26]. There are cases where very blue objects, emission-line selected, were also missed by most Markarian UV surveys [25] while on the contrary, only 20% of Markarian galaxies observed in Wasilewski [27] emission-line search were detected as emission-line objects. The existence of such cases is not a surprise. Within "combined surveys", in which both color and emission-line information are obtained the great majority of objects have emission-lines but only part of them possess a strong UV-excess radiation. What is the essence of this observational picture? Do some selection effects play a role or some intrinsic properties of different populations of star-forming galaxies? Petrosian et al. [28] address this problem by comparing the 524 SBS galaxies discovered via UV-excess radiation with 340 SBS galaxies discovered via the presence of line emission. The parameters used for the comparison were apparent magnitude, redshift, spectral class, luminosity, morphology, activity type, and close environment.

In the present paper, on the basis of spectroscopic observations of a large sample of the galaxies at 6-m telescope of Special Astrophysical Observatory (SAO, Russia), we aim once more to address this problem. All galaxies were discovered in Second Byurakan Sky Survey fields. The sample contains objects, which were selected from their emission-line spectra, and objects, which were selected from their UV-excess radiation. In Sec.2 we discuss the SBS field galaxies sample and two other sub-samples, we present the observations and data reduction and draw some results. In Sec.3 we compare several spectroscopic parameters of the two sub-samples of SBS field galaxies and analyze the results, which are discussed and conclusions are given in the last Sec.4.

Throughout the paper, we shall use $H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ for the Hubble constant.

## 2. *The Sample, Observations and Data Reduction.*

2.1. *The Sample.* The Second Byurakan Survey was conducted with the 1-m Schmidt telescope at the Byurakan Astrophysical Observatory in combination with a set of three objective prisms with refracting angles of 1.5, 3 and 4 degrees and Kodak IIIaJ and IIIaF backed plates [21]. The limiting magnitude of the survey is $19^m$-$20^m$. The objective prism survey plates cover the sky region defined by $7^h40^m \le \alpha \le 17^h20^m, 49° \le \delta \le 61°.2$, an area of about 1000 square degrees.

To achieve an effective and uniform survey, each area of the sky has been photographed several times on baked IIIaJ and IIIaF plates, first with 1°.5 prism and then with 3° and 4° prisms in conjunction with different filters. As in the case with the First Byurakan Survey (FBS, [19]) un-widened spectra were obtained and UV-excess objects were selected. As for the FBS, UV emitting regions were classified as stellar ("s") or diffuse ("d") according to the morphological appearance on their UV objective spectra. Intermediate classifications such as "sd" and "ds" also were used. A number between 1 and 3 was used to indicate the relative intensity of the UV emission with 1 being the strongest UV-excess. The 3° and 4° prisms were generally used to find weak and low-contrast emission-lines. Approximately all UV-excess galaxies, which were identified by 1°.5 prism observations, exhibit emission-line spectra in agreement with the observations of the 3° and 4° prisms. Besides, observations made with the 3° and 4° prisms have revealed a large number of new emission-line galaxies without excess UV radiation. In an area of about 1000 square degree 1401 UV-excess or emission-line galaxies were identified [29].

During the last one and half decade approximately half of SBS galaxies sample, preferably objects with strong or moderate emission-lines, were followed up spectrally at the 6-m telescope of the SAO. Several dozen galaxies, which were identified by an excess UV radiation or by their emission-lines in SBS fields, but were not included in SBS survey lists, were observed at the 6m telescope. For the aim of this present study, 111 objects with SAO calibrated spectra were selected out of 600 galaxies from the SBS fields. 77 of them were UV-excess selected from the 1°.5 prism observations. These galaxies will be referred in this paper as UV-excess galaxies (hereafter UVGs). 34 were discovered by their emission-line spectra according to the 3° or 4° prisms observations. These have not appreciable UV continuum radiation hence do not show up in the 1°.5 plates. Hereafter these galaxies will be refereed as Emission-line galaxies (ELGs).

2.2. *Observations and Data Reduction.* The follow-up spectroscopic observations were carried out during two nights of 11$^{th}$ and 12$^{th}$ of February 1991 with the 6-m telescope of SAO, Russia. A 1024-channel photon counter IPCS was used. Spectral resolution was about 4Å. Because of the low sensitivity of the IPCS in the red spectral range, observations were done only in the blue spectral range (on average from 3650 to 5550 Å). To remove the differences in sensitivity of the background and object detectors, two identical exposures of each galaxy were carried out step-by-step on the object slit and then on the background slit. Then, the obtained spectra were added together.

The reduction of the observations was done using standard procedures developed in SAO (SIPRAN) and Byurakan Observatory (AIDA). Reduction procedures include background subtraction, linearization of the spectra, wavelength and intensity calibrations.

For each object, a set of parameters were collected and are presented in Table 1, for the UVGs and in Table 2 for the ELGs. In both Tables, the column descriptions are as follows: Column 1: SBS field galaxy names. SBS names are taken from Bicay et al. [29]. Several galaxies are from Markarian's (e.g. [30]) and Case blue galaxies [31] lists; Column 2: Adopted spectral classes for the SBS field galaxies; Column 3: Apparent photographic magnitudes ($m_{pg}$), which are eye estimates from the POSS blue prints and are accurate to ±0.5 mag [29]; Column 4: Heliocentric redshifts ($z$), which were measured using [OII]$\lambda$3727, H$\beta$, [OIII]$\lambda$4959 and [OIII]$\lambda$5007 emission-lines (median standard deviation ($\sigma$) of velocity measurements is equal to 48 km s$^{-1}$); Column 5: Photographic absolute magnitudes ($M_{pg}$). No correction for Galactic absorption has been used since all galaxies are at high Galactic latitude and since apparent photographic magnitudes are given to within ±0.5 mag; Columns 6-7: Relative to H$\beta$ line intensities of [OII]$\lambda$3727, and [OIII]$\lambda$4959+5007. The uncertainty in these emission-lines ratios is in the order of 25%; Columns 8-10: Equivalent widths (in Angstroms) of [OII]$\lambda$3727, H$\beta$, and [OIII]$\lambda$5007 emission-lines;

Column 11: Color index of the continuum underlying [OII] λ3727 and Hβ emission-lines ($C_{[OII]} - C_{H\beta}$), which was calculated according to the formula (2) of Rola et al. [32]; Column 12: Notes.

Data of the Tables 1 and 2 have been used for the comparative study as well as for a detailed study of the UVGs and ELGs samples galaxies.

*Table 1*

UVGs: GALAXIES OF THE SBS FIELDS DISCOVERED *via* UV-EXCESS TECHNIQUE

| SBS | SC | $m_{pg}$ | z | $M_{pg}$ | [OII]/ Hβ | [OIII]/ Hβ | EW ([OII]) | EW (Hβ) | EW ([OIII]) | $C_{[OII]}$- $C_{H\beta}$ | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0745+601A | d2e | 18.0 | 0.0354 | -17.7 | 2.46 | 4.69 | 90.4 | 32.0 | 148.7 | 0.148 | |
| 0750+603A | ds2e | 17.5 | 0.0378 | -18.4 | 2.30 | 2.48 | 103.0 | 39.5 | 108.2 | 0.137 | |
| 0750+603B | ds2e | 17.5 | 0.0370 | -18.3 | 1.40 | 3.23 | 112.3 | 47.0 | 155.4 | 0.580 | |
| 0752+560B | s2e | 17.5 | 0.0288 | -17.8 | 2.96 | 2.95 | 67.0 | 19.7 | 57.8 | 0.151 | |
| 0755+536 | s3e | 16.0 | 0.0360 | -19.8 | 1.36 | 0.35 | 22.1 | 9.6 | 3.4 | 0.569 | Sy2 |
| 0755+588 | sd1e | 16.0 | 0.0202 | -18.5 | 2.23 | 1.37 | 96.1 | 27.2 | 38.5 | 0.499 | |
| 0935+585 | s2e | 18.0 | 0.0251 | -17.0 | 2.14 | 2.32 | 125.0 | 25.8 | 62.9 | 0.885 | |
| 0936+531 | ds2e | 18.0 | 0.0259 | -17.1 | 1.97 | 2.02 | 58.4 | 17.9 | 39.0 | 0.553 | |
| 0939+592 | sd2e | 15.5 | 0.0054 | -16.2 | 6.20 | 3.08 | 63.8 | 7.1 | 23.3 | 0.410 | Mrk1423 |
| 0940+508 | s1e | 18.0 | 0.0656 | -19.1 | 1.52 | 4.89 | 96.9 | 114.3 | 541.4 | -0.632 | |
| 0942+573 | sd1e | 16.0 | 0.0052 | -15.6 | 2.79 | 4.94 | 67.8 | 23.6 | 121.9 | 0.031 | Mrk1424 |
| 1006+578A | d3 | 17.0 | 0.0056 | -14.8 | 2.44 | 3.77 | 18.4 | 6.5 | 26.8 | 0.164 | BCD |
| 1009+586 | ds2e | 17.0 | 0.0314 | -18.5 | 2.36 | 2.92 | 67.4 | 25.0 | 70.8 | 0.146 | Mrk28 |
| 1054+596 | d2e | 18.5 | 0.0341 | -17.2 | 1.97 | 3.19 | 145.6 | 61.1 | 224.4 | 0.205 | |
| 1113+593 | ds2e | 17.0 | 0.0368 | -18.9 | 2.00 | 2.34 | 67.1 | 21.8 | 53.4 | 0.469 | |
| 1114+517 | ds2e | 16.5 | 0.0105 | -16.6 | 1.39 | 4.14 | 78.9 | 42.7 | 188.3 | 0.309 | Mrk1445 |
| 1119+601A | d2e | 17.5 | 0.0150 | -14.7 | 1.46 | 4.42 | 214.8 | 54.3 | 261.5 | 1.082 | BCD |
| 1120+586B | sd3e | 18.5 | 0.0382 | -17.4 | 1.71 | 3.23 | 119.3 | 39.2 | 154.0 | 0.627 | |
| 1124+541 | sd2e | 16.5 | 0.0107 | -16.7 | 1.08 | 4.86 | 96.4 | 108.9 | 597.9 | -0.214 | Mrk1446, BCD |
| 1124+610 | ds1e | 17.0 | 0.0336 | -18.6 | 3.26 | 2.24 | 97.2 | 25.8 | 59.8 | 0.157 | Sy2 |
| 1125+562 | sd2e | 16.0 | 0.0196 | -18.5 | 2.20 | 2.80 | 87.5 | 29.1 | 84.8 | 0.336 | Sy2 |
| 1132+578 | sd1e | 18.5 | 0.0310 | -17.0 | 2.48 | 3.51 | 82.5 | 20.8 | 73.3 | 0.508 | |
| 1140+537 | sd1e | 16.5 | 0.0294 | -18.9 | 2.59 | 2.57 | 106.2 | 67.6 | 194.2 | -0.542 | Mrk1451 |
| 1152+579 | d1e | 16.5 | 0.0185 | -17.8 | 0.95 | 4.45 | 129.2 | 184.3 | 450.2 | -0.461 | Mrk193 |
| 1155+588 | ds2e | 17.5 | 0.0654 | -19.6 | 2.70 | 4.46 | 78.4 | 30.1 | 146.3 | -0.036 | Sy2 |
| 1203+592 | d2e | 17.0 | 0.0110 | -16.4 | 2.16 | 3.90 | 214.6 | 118.8 | 569.8 | -0.192 | BCD |
| 1215+558 | ds2e | 17.5 | 0.0327 | -18.1 | 3.05 | 1.73 | 121.9 | 29.1 | 51.9 | 0.343 | Sy2 |
| 1216+551 | sd1e | 17.7 | 0.0190 | -16.7 | 2.71 | 3.35 | 50.8 | 9.1 | 31.2 | 0.786 | BCD |
| 1221+585 | ds3e | 17.5 | 0.0149 | -16.4 | 0.36 | 4.77 | 12.7 | 12.5 | 60.3 | 1.115 | BCD |
| 1221+602 | d1e | 17.5 | 0.0245 | -17.5 | 2.18 | 2.57 | 47.7 | 18.8 | 48.4 | 0.163 | |
| 1223+537A | s3 | 18.5 | 0.0516 | -17.3 | 3.47 | 2.41 | 105.9 | 18.2 | 44.4 | 0.562 | Sy2 |
| 1223+537B | ds1e | 18.0 | 0.0530 | -18.6 | 0.97 | 6.10 | 140.3 | 149.0 | 920.4 | -0.035 | |
| 1224+561A | ds3e | 17.0 | 0.0522 | -19.6 | 3.40 | 5.89 | 38.6 | 3.7 | 22.1 | 1.214 | LINER |
| 1227+568B | sd1e | 18.0 | 0.0542 | -18.7 | 1.74 | 2.17 | 45.5 | 11.4 | 28.3 | 0.899 | |
| 1230+560 | ds2e | 17.0 | 0.0339 | -18.7 | 3.09 | 1.28 | 77.8 | 14.9 | 19.6 | 0.571 | |
| 1242+549 | sd1e | 16.0 | 0.0168 | -18.1 | 1.23 | 3.35 | 60.5 | 66.2 | 263.4 | -0.319 | |
| 1250+594 | sd2e | 18.0 | 0.0454 | -18.3 | 3.25 | 2.48 | 89.9 | 28.1 | 75.5 | -0.015 | |
| 1303+537 | d3e | 16.0 | 0.0248 | -19.0 | 3.62 | 3.45 | 37.2 | 9.3 | 33.4 | 0.108 | Mrk242 |
| 1312+550 | s1e | 15.0 | 0.0333 | -20.6 | 2.04 | 1.21 | 36.8 | 20.5 | 22.0 | -0.137 | Mrk247 |
| 1314+605 | d2e | 17.5 | 0.0075 | -14.9 | 4.90 | 4.36 | 97.9 | 20.3 | 93.4 | -0.016 | BCD |

*Table 1 (the end)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1315+593 | ds2e | 17.5 | 0.0293 | -17.8 | 3.38 | 3.40 | 38.8 | 6.9 | 24.9 | 0.560 | |
| 1317+523C | d3e | 16.0 | 0.0165 | -18.1 | 3.88 | 2.63 | 60.5 | 14.1 | 38.4 | 0.111 | |
| 1319+593 | d1 | 15.5 | 0.0439 | -20.7 | 3.80 | 2.17 | 60.0 | 13.7 | 30.7 | 0.153 | Mrk65 |
| 1323+575 | d3e | 15.0 | 0.0212 | -19.6 | 4.09 | 3.70 | 42.1 | 10.5 | 39.3 | -0.018 | Mrk66 |
| 1331+493 | s2e | 14.9 | 0.0028 | -15.4 | 0.95 | 3.58 | 88.8 | 122.1 | 475.8 | -0.140 | BCD |
| 1332+518 | ds2e | 14.2 | 0.0015 | -15.5 | 4.58 | 4.12 | 17.7 | 3.9 | 16.7 | -0.007 | Mrk1479 |
| 1332+545 | sd1e | 18.0 | 0.0516 | -18.6 | 3.56 | 3.27 | 72.5 | 12.7 | 46.0 | 0.512 | Sy2 |
| 1340+529 | sd1c | 16.5 | 0.0068 | -15.7 | 2.40 | 3.00 | 109.9 | 66.6 | 198.5 | -0.409 | Mrk1480, BCD |
| 1341+594 | d2e | 17.5 | 0.0110 | -15.7 | 3.30 | 3.28 | 105.4 | 31.2 | 108.9 | 0.026 | BCD |
| 1352+589 | sd2e | 18.0 | 0.0255 | -17.1 | 1.30 | 4.46 | 43.8 | 27.7 | 37.4 | 0.214 | |
| 1354+580 | sd1e | 17.5 | 0.0282 | -17.8 | 3.57 | 4.24 | 109.7 | 25.0 | 106.0 | 0.225 | |
| 1358+554 | sd2e | 17.5 | 0.0138 | -16.2 | 2.31 | 3.10 | 19.0 | 28.8 | 60.4 | -0.544 | BCD |
| 1404+571 | sd2c | 16.5 | 0.0420 | -19.8 | 2.09 | 1.11 | 47.1 | 21.9 | 24.5 | 0.033 | |
| 1411+556A | ds3e | 16.5 | 0.0420 | -19.7 | 4.76 | 2.22 | 47.7 | 5.1 | 12.0 | 0.727 | LINER |
| 1411+584 | s2 | 18.0 | 0.0755 | -19.4 | 1.12 | 1.49 | 19.6 | 9.9 | 16.0 | 0.613 | |
| 1422+573 | d3e | 15.0 | 0.0111 | -18.4 | 3.81 | 2.39 | 32.9 | 9.0 | 23.0 | -0.050 | Mrk812 |
| 1426+573 | ds3e | 17.5 | 0.0438 | -18.7 | 1.30 | 7.22 | 46.0 | 18.9 | 137.5 | 0.683 | |
| 1430+526 | ds2e | 17.0 | 0.0109 | -16.4 | 2.12 | 5.25 | 50.4 | 30.5 | 144.3 | 0.077 | BCD |
| 1446+595 | d2e | 18.0 | 0.0081 | -14.6 | 1.47 | 5.01 | 53.1 | 29.5 | 166.6 | 0.220 | BCD |
| 1453+526 | sd1e | 17.0 | 0.0115 | -16.3 | 2.86 | 3.66 | 178.4 | 83.2 | 344.5 | -0.311 | BCD |
| 1458+497 | ds1e | 17.0 | 0.0493 | -19.5 | 2.90 | 2.09 | 78.6 | 19.4 | 40.6 | 0.362 | |
| 1509+527 | sd3e | 15.6 | 0.0129 | -18.0 | 4.88 | 4.69 | 36.3 | 9.0 | 37.6 | 0.077 | |
| 1511+515A | ds2e | 16.5 | 0.0372 | -19.4 | 1.91 | 0.74 | 64.9 | 34.1 | 27.4 | 0.000 | |
| 1519+508A | ds1e | 15.5 | 0.0573 | -21.3 | 0.99 | 0.43 | 15.1 | 27.7 | 14.4 | -0.571 | |
| 1529+548 | d2e | 15.1 | 0.0398 | -21.0 | 2.21 | 2.36 | 45.4 | 26.8 | 66.4 | -0.290 | Mrk484 |
| 1531+580 | d3e | 15.5 | 0.0406 | -20.6 | 1.60 | 1.54 | 55.8 | 48.4 | 72.6 | -0.353 | Mrk289 |
| 1533+469 | sd1 | 16.0 | 0.0195 | -18.5 | 2.09 | 4.85 | 79.7 | 40.5 | 186.8 | -0.068 | |
| 1556+583 | s1e | 15.3 | 0.0354 | -20.5 | 2.40 | 3.09 | 33.9 | 21.1 | 45.7 | -0.436 | Mrk865 |
| 1558+585 | sd2e | 17.5 | 0.0147 | -16.3 | 1.38 | 1.38 | 30.3 | 11.9 | 15.9 | 0.660 | BCD |
| 1559+585 | ds2e | 14.8 | 0.0146 | -19.0 | 3.65 | 2.24 | 35.4 | 8.4 | 20.0 | 0.159 | |
| 1610+586 | ds2e | 17.0 | 0.0458 | -19.3 | 2.56 | 1.73 | 62.3 | 22.7 | 41.6 | 0.078 | |
| 1614+600 | s1e | 18.5 | 0.0312 | -17.0 | 2.37 | 2.29 | 80.4 | 34.7 | 84.9 | -0.025 | |
| 1634+523 | ds1e | 15.6 | 0.0092 | -17.5 | 2.49 | 2.93 | 169.0 | 59.5 | 173.8 | 0.146 | Mrk1499 |
| 1640+516 | sd1e | 15.6 | 0.0318 | -19.9 | 3.33 | 2.36 | 74.8 | 21.2 | 52.2 | ·0.064 | Mrk1500 |
| Mrk222 | d2 | 16.5 | 0.0170 | -17.7 | 2.37 | 3.67 | 94.0 | 46.1 | 172.1 | -0.162 | |
| Mrk224 | d3 | 16.2 | 0.0046 | -15.1 | 2.35 | 3.74 | 90.7 | 56.5 | 237.8 | -0.412 | |
| Mrk229 | d2e | 17.0 | 0.0246 | -18.0 | 1.75 | 2.78 | 162.2 | 125.2 | 320.2 | -0.326 | |

*Table 2*

## ELGs: GALAXIES OF THE SBS FIELDS DISCOVERED *via* EMISSION-LINE TECHNIQUE

| SBS | SC | $m_{pg}$ | z | $M_{pg}$ | [OII]/Hβ | [OIII]/Hβ | EW ([OII]) | EW (Hβ) | EW ([OIII]) | $C_{[OIII]}$-$C_{H\beta}$ | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0743+591B | se | 18.5 | 0.0229 | -16.3 | 1.59 | 4.05 | 132.8 | 113.5 | 418.6 | -0.045 | BCD |
| 0750+559 | dse | 17.5 | 0.0263 | -17.6 | 2.33 | 0.92 | 46.4 | 10.9 | 102.9 | 0.655 | |
| 0756+553 | sde | 17.5 | 0.0364 | -18.3 | 1.02 | 1.07 | 49.6 | 15.7 | 11.2 | 1.227 | |
| 0805+577 | sde | 18.0 | 0.0280 | -17.2 | 0.21 | 0.19 | 88.0 | 28.3 | 58.6 | 0.911 | |
| 0811+583 | de | 17.5 | 0.0289 | -17.8 | 3.35 | 3.02 | 87.7 | 14.8 | 47.1 | 0.617 | Sy2 |
| 1128+573 | sde | 18.5 | 0.0062 | -13.5 | 1.28 | 8.40 | 236.8 | 77.2 | 680.5 | 0.953 | BCD |
| 1129+577 | de | 15.3 | 0.0055 | -16.4 | 1.10 | 2.41 | 76.1 | 98.4 | 297.1 | -0.380 | BCD |

*Table 2 (the end)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1134+598 | de | 19.0 | 0.0327 | -16.6 | 1.89 | 8.80 | 65.8 | 40.4 | 365.7 | -0.158 | BCD |
| 1136+607 | se | 18.0 | 0.0125 | -15.5 | 3.52 | 3.47 | 133.3 | 24.3 | 83.2 | 0.481 | BCD |
| 1137+589 | se | 18.0 | 0.0074 | -14.4 | 2.45 | 5.37 | 89.0 | 25.7 | 202.6 | 0.379 | BCD |
| 1159+516B | de | 17.5 | 0.0151 | -16.4 | 1.81 | 1.60 | 148.4 | 60.2 | 96.0 | 0.334 | BCD |
| 1200+589B | de | 18.5 | 0.0329 | -17.1 | 1.29 | 4.82 | 75.7 | 111.8 | 685.3 | -0.698 | |
| 1200+589C | sde | 18.5 | 0.0330 | -17.1 | 2.18 | 4.04 | 54.1 | 31.6 | 167.3 | -0.262 | |
| 1214+564 | de | 17.5 | 0.0528 | -19.1 | 1.53 | 1.54 | 70.7 | 30.7 | 39.6 | 0.714 | |
| 1223+557 | de | 17.0 | 0.0524 | -19.6 | 1.28 | 7.03 | 171.5 | 130.3 | 905.1 | 0.027 | |
| 1225+571 | de | 17.5 | 0.0281 | -17.8 | 4.42 | 1.45 | 69.0 | 7.1 | 10.5 | 0.850 | LINER |
| 1226+542 | de | 19.0 | 0.0421 | -17.1 | 1.98 | 6.70 | 537.5 | 115.4 | 770.5 | 0.929 | |
| 1319+539 | de | 18.5 | 0.0339 | -17.2 | 1.95 | 5.18 | 142.3 | 126.0 | 637.0 | -0.595 | |
| 1319+539E | de | 17.5 | 0.0343 | -18.2 | 1.29 | 1.54 | 46.1 | 35.7 | 54.8 | 0.000 | |
| 1354+597 | de | 17.5 | 0.0104 | -15.6 | 2.25 | 0.79 | 49.7 | 16.8 | 14.1 | 0.299 | BCD |
| 1401+490 | de | 16.5 | 0.0038 | -14.4 | 2.22 | 3.50 | 173.9 | 109.5 | 476.1 | -0.364 | BCD |
| 1428+457 | ds | 15.2 | 0.0089 | -17.6 | 2.44 | 2.23 | 146.1 | 91.9 | 211.8 | -0.466 | |
| 1504+514 | sde | 16.0 | 0.0132 | -17.6 | 2.71 | 3.83 | 247.9 | 58.7 | 250.3 | 0.482 | |
| 1523+519 | de | 18.1 | 0.0126 | -15.4 | 2.19 | 5.29 | 101.0 | 39.3 | 285.5 | 0.278 | BCD |
| 1541+590 | se | 19.5 | 0.0450 | -16.8 | 1.25 | 8.07 | 146.2 | 117.1 | 943.5 | 0.000 | BCD |
| 1607+493 | de | 17.5 | 0.0430 | -18.7 | 3.10 | 4.48 | 147.9 | 67.4 | 409.9 | -0.375 | |
| 1616+503 | dse | 16.3 | 0.0433 | -19.9 | 0.98 | 6.96 | 21.2 | 12.0 | 81.8 | 0.642 | |
| CG368 | se | 17.5 | 0.0350 | -18.2 | 2.78 | 3.84 | 96.4 | 33.8 | 140.4 | 0.026 | |
| CG564 | de | 14.1 | 0.0092 | -18.7 | 2.27 | 3.69 | 86.7 | 22.7 | 85.2 | 0.567 | |
| CG587 | se | 17.1 | 0.0126 | -16.4 | 2.21 | 5.00 | 98.1 | 25.2 | 136.0 | 0.612 | BCD |
| CG597 | dse | 17.0 | 0.0392 | -19.0 | 2.39 | 2.78 | 82.8 | 28.1 | 86.0 | 0.230 | |
| CG608 | se | 16.3 | 0.0117 | -17.0 | 2.63 | 3.35 | 101.3 | 22.1 | 76.7 | 0.604 | |
| CG642 | sde | 18.0 | 0.0489 | -18.5 | 1.43 | 3.82 | 201.8 | 160.8 | 614.4 | -0.138 | |
| CG657 | se | 16.0 | 0.0545 | -20.7 | 1.75 | 2.76 | 170.1 | 112.2 | 317.6 | -0.157 | |

3. *Results.* We have compared the samples of SBS field galaxies discovered via UV-excess and EL techniques. Besides of the general comparison of the UVGs and ELGs samples, we also examine each sample in detail.

3.1. *A Comparison of the UVGs and ELGs samples.* Since apparent magnitudes, redshifts and luminosities of the SBS UVGs and ELGs were compared previously for much larger samples of galaxies [28] here we will carry out only the comparison of the spectrophotometric parameters of the galaxies samples.

Table 3 presents the median values of blue luminosities $M_{pg}$, [OII]/H$\beta$, and [OIII]/H$\beta$ emission-line ratios, equivalent widths of [OII]$\lambda$3727, [OIII]$\lambda$5007 and H$\beta$ lines as well as the $C_{[OII]} - C_{H\beta}$ index for the UVGs and ELGs.

*Table 3*

MEDIANS FOR THE UVGs AND ELGs

| | $M_{pg}$ | [OII]/H$\beta$ | [OIII]/H$\beta$ | EW([OII]) | EW(H$\beta$) | EW([OIII]) | $C_{[OII]} - C_{H\beta}$ |
|---|---|---|---|---|---|---|---|
| UVGs | -18.1 | 2.36 | 3.09 | 67.8 | 25.8 | 60.4 | 0.146 |
| ELGs | -17.2 | 2.08 | 3.76 | 97.2 | 37.5 | 184.9 | 0.288 |

In Table 3 the larger (about three times) and less larger difference in median equivalent widths of [OIII] $\lambda$5007 and H$\beta$ lines for UVGs and ELGs are in agreement with their difference in median of the [OIII]/H$\beta$ ratio (e.g. [33]). Since at the same time the median absolute magnitude of the UVGs is 0.9 magnitude brighter than the median absolute magnitude of the ELGs, all these facts come together to re-enforce a known result: low luminosity star-forming galaxies have on average higher excitation parameters and emission-lines equivalent widths than intrinsically high luminosity objects [33,34]. The fact that UV-excess galaxies have bluer continua than galaxies discovered from their emission-lines only is obvious.

The number of AGNs in UVGs sample is 9 (12% of the sample) and in ELGs sample is 2 (6% of the sample). The picture is similar to that by Petrosian et al. [28]. The number of Blue Compact Dwarf galaxies (BCDGs) in the UVGs sample is 6 (8% of the sample) and 12 in the ELGs sample (35% of the sample). In our sample of 111 SBS field galaxies, about four times more BCDGs were discovered from their emission-line than from their UV-excess properties. The excess of AGNs in the UVGs sample and the excess of BCDGs in the ELGs sample play in favor of the above results.

3.2. *A Comparison of the UVGs according to their UV emission intensity. The role of the compactness of the emitting region.* One interesting problem to study is the relation between the relative intensity of the UV emission and the spectroscopic parameters of the UVGs. Among 77 UVGs in our sample, 25 are objects with the strongest UV-excess radiation (hereafter UV1), 37 are intermediate (UV2) and 15 are objects with the faintest UV-excess radiation (UV3). Table 4 presents the median values of the luminosities, [OII]/H$\beta$, and [OIII]/H$\beta$ emission-line ratios, the equivalent widths of [OII] $\lambda$3727, [OIII] $\lambda$5007 and H$\beta$ as well as the $C_{[OII]}-C_{H\beta}$ index for these sub-classes of galaxies.

*Table 4*

MEDIANS FOR THE UVGs WITH STRONGEST (UV1), INTERMEDIATE (UV2), AND FAINTEST (UV3) UV-EXCESS RADIATION

| | $M_{pg}$ | [OII]/H$\beta$ | [OIII]/H$\beta$ | EW([OII]) | EW(H$\beta$) | EW([OIII]) | $C_{[OII]}-C_{H\beta}$ |
|---|---|---|---|---|---|---|---|
| UV1 | -18.5 | 2.40 | 3.00 | 79.7 | 25.8 | 73.3 | 0.031 |
| UV2 | -17.7 | 2.20 | 3.08 | 77.8 | 28.8 | 70.8 | 0.148 |
| UV3 | -18.4 | 3.40 | 3.45 | 42.1 | 10.5 | 38.4 | 0.164 |

Table 4 shows that the median equivalent widths of the [OII], H$\beta$ and [OIII] lines, the [OII]/H$\beta$ ratio, as well as the $C_{[OII]}-C_{H\beta}$ index of the UV3 (faintest UV-excess radiation) differ dramatically from the medians of the same parameters for the two other sub-classes UV1 and UV2. Comte et al.

[23] report similar trend for the emission-line equivalent widths of the Kiso galaxies with "high", "intermediate", and "low" UV-excess radiation. This result is not surprising since most AGNs, particularly LINERS (Sy3 galaxies) are objects with the faintest UV-excess radiation. Redder continua, higher [OII]/Hβ ratio, and lower equivalent widths of forbidden and Hβ lines are typical for these galaxies (e.g. [32]).

In the combined sample of UVGs and ELGs, 64 galaxies have diffuse and semi-diffuse (d + ds) spectral classes and 47 stellar and semi-stellar (s+sd). Table 5 presents the median values for all derived spectrophotometric parameters as well as the luminosities of these two sub-samples of UV-excess and emission-line galaxies.

*Table 5*

MEDIANS FOR UVGs AND ELGs WITH DIFFUSE AND SEMI-DIFFUSE (d + ds), AND STELLAR AND SEMI-STELLAR (s + sd) EMISSION REGIONS

| | $M_{pg}$ | [OII]/Hβ | [OIII]/Hβ | EW([OII]) | EW(Hβ) | EW([OIII]) | $C_{[OII]} - C_{H\beta}$ |
|---|---|---|---|---|---|---|---|
| d+ds | -17.9 | 2.26 | 3.21 | 75.9 | 29.3 | 85.6 | 0.147 |
| s+sd | -17.4 | 2.21 | 3.27 | 88.0 | 27.2 | 83.2 | 0.151 |

Table 5 shows that median spectrophotometric parameters as well as luminosities are approximately the same for the UV-excess and emission-line galaxies with diffuse or semi-diffuse, and stellar or semi-stellar emission regions.

3.3. *Multivariate Factor Analysis.* As a further general exploration of the data related to the spectrophotometric properties of the UVGs and ELGs we applied the Multivariate Factor Analysis (MFA) method to our samples. The MFA is a statistical method for detecting correlations among a set of *m* initial variables measured on *n* objects through a reduced number ($p < m$) of linearly independent factors *F1*, *F2*, ..., *Fp* that account for the correlations. This method has been used in astronomy by several authors (e.g. [35,36]). A detailed description of the MFA method can be found in Harman [37] and Afifi & Azen [38].

The initial *m* variables used for the UVGs and ELGs were:

- the spectral class SC, with SC = 1 for the galaxies discovered by the UV-excess technique and SC = 2 for the galaxies discovered with the emission-line technique;

- the compactness *C* of the UV (for UVGs) or continuum (for ELGs) emission region, with $C = 1$ for galaxies with "stellar" s, $C = 2$ for galaxies with "semi-stellar" sd, $C = 3$ for "semi-diffuse ds and $C = 4$ for "diffuse d class spectra;

- the relative intensity UV-ex of UV-excess radiation or its absence, with UV-ex = 1 for strongest, UV-ex = 2 for intermediate, UV-ex = 3 for the faintest UV-excess radiation, and UV-ex = 4 for the cases when UV-excess radiation is absent;

- the absolute photographic magnitude $M_{pg}$; the [OII]/Hβ and [OIII]/Hβ emission-line ratios; the equivalent widths EW([OII]), EW(Hβ), and EW([OIII],

- the $C_{[OII]} - C_{H\beta}$ index,

- and finally a parameter AGN for nuclear activity with AGN = 0 for normal and 1 for active nuclei.

In order to present each initial variable with the smaller number of common factors for an easier interpretation of the results, we apply the Varimax orthogonal rotation to the first four factors *Fi* ($i = 1$ to 4).

*Table 6*

VARIMAX ROTATED FACTOR SCORES MATRIX FOR 77 UVGs AND 34 ELGs SAMPLES

| | *F1* | *F2* | *F3* | *F4* |
|---|---|---|---|---|
| SC | -0.166 | 0.910 | 0.181 | 0.026 |
| *C* | 0.182 | 0.197 | 0.023 | 0.787 |
| UV-ex | 0.026 | 0.941 | 0.142 | 0.065 |
| $M_{pg}$ | 0.138 | 0.087 | 0.656 | -0.170 |
| [OII]/Hβ | 0.759 | -0.219 | 0.011 | 0.278 |
| [OIII]/Hβ | -0.089 | 0.052 | 0.772 | 0.023 |
| EW([OII]) | -0.209 | 0.198 | 0.688 | 0.108 |
| EW(Hβ) | -0.718 | 0.062 | 0.512 | 0.298 |
| EW([OIII]) | -0.582 | 0.135 | 0.700 | 0.209 |
| $C_{[OII]} - C_{H\beta}$ | 0.514 | 0.304 | 0.026 | -0.603 |
| AGN | 0.537 | 0.020 | -0.048 | 0.007 |
| Accumulated Variance (%) | 19 | 37 | 58 | 69 |

In Table 6 the Varimax rotated factor scores and the accumulated dispersions of the first four factors *Fi* ($i = 1$ to 4), for a total of 69% of the common variance, are presented. Factor scores are the correlation coefficients between the initial variables and the factors *Fi*. Adopting a correlation threshold of $r \approx 0.7$ we find that the first factor *F1*, correlates the [OII]/Hβ intensity ratio with the equivalent width of Hβ. Since both parameters depend on the intensity of Hβ, the result is somehow expected. Because the equivalent widths strongly depend on the level of the continuum radiation for a given object, the observed correlation (correlation threshold level is between 0.583-0.209) between Hβ and the oxygen lines equivalent widths is obvious (see also Fig.6 of Comte et al. [23]). This factor correlates also the type (AGN) at a $r = 0.537$ threshold level. AGNs tend to have higher [OII]/Hβ ratios and lower Hβ equivalent widths (e.g. Rola et al. [32]). Observed at $r = 0.514$ threshold level, the correlation between spectral index $C_{[OII]} - C_{H\beta}$ and the factor *F1* is also expected. Objects with redder continuum radiation (higher values of $C_{[OII]}-C_{H\beta}$ index, Rola et al. [32]) are very often AGNs with small emission-lines equivalent widths and large [OII]/H$\beta$ ratios. The second factor *F2*, correlates the spectral class with the relative intensity of the UV-excess radiation; hence stronger UV-excess radiation objects were discovered via UV-excess technique, which is obvious. Since according to Rola et al. [32] larger $C_{[OII]}-C_{H\beta}$ values correspond to redder continua, the observed correlation between $C_{[OII]}-C_{H\beta}$ and spectral class as well as UV-ex is also obvious (in *F2* at $r = 0.304$ threshold level). Redder objects have fainter or no UV-excess radiation and were mostly discovered via emission-line technique. The third factor *F3*, correlates [OIII]/H$\beta$ ratio, and at a threshold level between 0.688-0.512 the equivalent widths of observed lines, which is expected. It is well known that higher values of the excitation parameter - [OIII]/H$\beta$ are typical for dwarf star-forming galaxies (Blue Compact Dwarfs or Dwarf Irregulars) with low level of continuum radiation (e.g. [39, 34]) and high equivalent widths. This is proved by the correlation of $M_{pg}$ with F3 at a threshold level of 0.656. The factor four, *F4*, only depends on the compactness ($C$) of the UV (for UVGs) or continuum (for ELGs) emitting region. The same factor correlates the $C_{[OII]}-C_{H\beta}$ index at a level of 0.604, indicating that bluer galaxies have more diffuse UV or continuum emission regions. Since dwarf star-forming galaxies in our sample are mostly diffuse, this is an expected result.

4. *Discussion and Conclusions*. Petrosian et al. [28] have conducted a study with the goal to further illuminate the discussion of the nature and origin of activity and star formation in galaxies and to clarify possible observational selection effects. They achieved a thorough comparative study of the integral properties of a large sample of SBS galaxies discovered with a combination of UV-excess and emission-line techniques. Results presented by Petrosian et al. [28] indicate that the combination of UV-excess with the emission-line techniques of the Second Byurakan Survey has led to the discovery of active and star-forming galaxies with a broad range of the integral parameters. Both techniques are unique by their approach and strengthen each other, helping to create deeper and larger intervals of redshift sample. The UV-excess technique preferentially discovers high luminosity active galaxies while emission-line technique remains preferable for the discovery of low luminosity galaxies, mostly with diffuse morphological structure.

Spectrophotometric parameters chosen for this study are related to the activity and star-forming properties of the sample galaxies. For star-forming galaxies, equivalent widths and emission-lines intensities are related to the present day star formation rate since the observed sources are mostly OB stars. For the galaxies hosting AGNs, the situation is more complicated. According to the current studies, mostly for the Sy2 and LINER type active galaxies, a circumnuclear starburst can play a crucial role in the AGN phenomena (e.g. [40,41]). In this case, observed equivalent widths and emission-line intensity ratios can be interpreted according to this "combined" approach. In several papers (e.g. [42,43,32]) the classification methods can identify active and star-forming galaxies according to their emission-line spectra. We find that the diagnostic diagrams of Rola et al. [32] were more appropriate for our comparative study. Calculated medians of [OII]/Hβ and [OIII]/Hβ emission-lines ratios, equivalent widths of [OII], Hβ and [OIII] emission-lines and continuum color index $C_{[OII]} - C_{H\beta}$ were checked with Rola et al. [32] diagnostic diagrams. They were compared with the luminosities and the rates of active and dwarf star-forming galaxies in the samples of the UV-excess and emission-line galaxies. Our conclusions can be summarized as follows:

1. Galaxies discovered *via* UV-excess technique in comparison to the galaxies discovered *via* emission-line technique have: higher median luminosity; lower $C_{[OII]} - C_{H\beta}$ index (which corresponds to the bluer continuum radiation); lower emission-lines equivalent widths (which result from the higher level of the continuum radiation); higher [OII]/Hβ and lower [OIII]/Hβ emission-lines ratios (from LINERs and Sy2 galaxies). High excitation low luminosity star-forming galaxies are more found via emission-line technique.

2. UV-excess galaxies with faint UV-excess radiation have the reddest and more powerful continuum spectra hence lower emission lines equivalent widths. Since most AGNs in UV-excess galaxies sample are objects with faintest UV-excess radiation, they are expected to have higher median of [OII]/Hβ lines ratio.

3. Diffuseness of the UV-excess or emission-line emitting region has no significant impact on the spectrophotometric properties of the UV-excess and emission-line galaxies.

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## СПЕКТРОСКОПИЧЕСКОЕ ИССЛЕДОВАНИЕ БОЛЬШОГО КОЛИЧЕСТВА ГАЛАКТИК, ОБНАРУЖЕННЫХ В ОБЛАСТЯХ ВТОРОГО БЮРАКАНСКОГО ОБЗОРА

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Второй Бюраканский обзор (SBS) - хорошо известный комбинированный обзор, в котором для идентификации активных галактик и галактик с звездообразованием используется наличие УФ-избыточного излучения в континууме или наличие эмиссионных линий в спектрах. Эта статья о сравнительном исследовании 77 галактик с УФ-избытком и 34 галактик с эмиссионными линиями без УФ-избытка из SBS. Для сравнения, в качестве спектроскопических параметров, были использованы отношения [OII]$\lambda$3727/$H_\beta$ и [OIII]$\lambda$5007/$H_\beta$, эквивалентные ширины [OII]$\lambda$3727, [OIII]$\lambda$5007 и H$\beta$ эмиссионных линий, и $C_{[OII]\lambda3727} - C_{H\beta}$ индекс. Спектроскопические параметры и красные смещения были определены по спектрам, полученным 6-м телескопом Специальной астрофизической обсерватории (Россия). Основные результаты: 1) Галактики, обнаруженные по наличию УФ-избытка, в основном более активные. 2) Галактики, обнаруженные по эмиссионным линиям, в большинстве случаев имеют высокую степень возбуждения, но низкую светимость и являются галактиками со звездообразованием. 3) Галактики с УФ-избытком со слабым УФ-избыточным излучением являются вероятными кандидатами LINER или Sy2 объектов.

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