THE SECOND BYURAKAN SPECTRAL SKY SURVEY

B.E.Markarian, J.A.Stepanian, L.K.Erastova
Byurakan Astrophysical Observatory,
378433 Armenia, USSR

ABSTRACT. The method of the Second Spectral Survey carried out with the Byurakan 1-m Schmidt telescope is discussed. The limiting magnitude is fainter in comparison with the First Byurakan Survey at about $2.-3^m$.

The results of low dispersion (500 objects) and slit spectroscopy (300 objects) based on observations with the 6-m telescope of Special Astrophysical Observatory for four fields of the Second Survey are presented.

The luminosity function of faint UV galaxies is discussed. The completeness of AGN of the Second Survey and their surface and space densities are also estimated. The surface density of QSO and ELG is estimated and these data are compared with the results of other surveys.

New observational data obtained with the 6-m telescope are compared with the new data of different deep surveys carried out during last years.

1. INTRODUCTION.

In the middle of the fifties the idea of the fundamental role of the galactic nuclei on the formation and further evolution of the whole galaxy was expressed by V.A.Ambartsumian. This idea stimulated many investigations in extragalactic research during last 30 years and attracted general attention to the problem of the origin of the galactic nuclei (Ambartsumian, 1956, 1958).

Twenty years ago in May 1966 at the IAU Symposium No. 29, which took place at Byurakan, B.E.Markarian presented the report "The galaxies with UV Continuua" (Markarian, 1968). So, he initiated the First Byurakan Spectral Sky Survey (FBS), as it is called today.

The First Survey is now finished. About 1500 peculiar extragalactic objects known in literature as "Markarian's galaxies" have been discovered. As a matter of fact this survey was the first systematic search for galaxies with

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active nuclei(AGN).It is described in more details in the paper by Lipovetskij et al(in this volume).The First Survey stimulated the beginning of similar surveys undertaken today all over the world. And so, twenty years ago B.E.Markarian at Byurakan Observatory initiated a new direction in extragalactic astronomy - systematic search for new extragalactic populations.

2. THE SECOND BYURAKAN SPECTRAL SKY SURVEY - SBS.

In 1975 at the Byurakan Observatory with the 40-52" Schmidt telescope by B.E.Markarian and his collaborators(Markarian et al 1983a, 1985, 1986;Markarian and Stepanian,1983, 1984a,b) the Second Byurakan Spectral Sky Survey was started. The Second Survey which is the continuation of the First one, aims at the spread of the low dispersion spectral investigations of as faint objects as possible.

The basic differences of the Second Survey from the First one are: use of other types of photographic emulsions - nitrogen - baked Kodak IIIaJ and IIIaF,applying during the observations of all three prisms - $1\overset{\circ}{.}5$, $3^{\circ}$and 4°, the essentially improved limiting magnitude up to $19\overset{m}{.}5$, the finding of the new types peculiar objects, systematic selection of all the types of stellar objects, among which QSO and AGN are expected.

In Table 1 basic data of the method of SBS observation brought together.

Table 1

Prism	Emulsion Filter	Diaphragm (mm)	Spect. band	Exp. (min)	Disper. A/mm	Limit. magn.
$1\overset{\circ}{.}5$	IIIaJ	1000	3500-5350	30	1800 H_{γ}	19.5.
3	IIIaJ+GG495	900	4900-5350	120	1400 5100	19.5
4	IIIaF+RG2	800	6300-6850	120	1097 H_{α}	19.5

In the SBS Survey five types of objects were selected:
1. Candidates of quasistellar objects - QSO
2. Blue stellar objects - BSO
3. Blue stars - BS
4. Galaxies with UV continua - UVX galaxies
5. Emission line galaxies - ELG.

More detailed information about the observational methods, search and objects selection can be found in Stepanian (1984a).

The Second Survey is located in the region of the sky with $8^{h} < \alpha < 17^{h}$, $49^{\circ} < \delta < 61^{\circ}$. Now the study of five fields of SBS were finished (Markarian and Stepanian,1983, 1984a,b; Markarian et al, 1985,1986), each of them covers the area of 4x4 degrees. Here we represent the results of investigation for four fields.

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On these four fields on the low dispersion plates 476 objects were discovered. The distribution of objects of its types is presented in Table 2.

Table 2

Position of the field center	UVX	ELG	QSO	BSO	BS	In all
08^h00^m $+59^\circ00'$	21	54	6	13	12	106
09 50 +55 00	24	39	20	27	24	134
11 30 +59 00	29	56	11	11	11	118
12 22 +55 00	32	29	16	29	12	118
In all	106	178	53	80	59	476

As one can see from this Table, about 40% of objects are stellar ones and 60% are galaxies. Slit spectra of the SBS objects for more detailed investigation were obtained with the 6m telescope with the UAGS spectrograph and Tubes of the types UM-92 and UMK-91B. Inwidened spectra in spectral range $\lambda\lambda$ 3500-5700 were obtained with dispersion about 90-100 A/mm and spectral resolution 5-10 A. During the last years the observations were carried out with the TV 1000-channel Photon Counting System of BTA. During last 8 years we obtained slit spectra for 333 from 476 objects.

3. UVX GALAXIES AND EMISSION LINE GALAXIES.

On these four fields 108 new UVX galaxies and 178 ELG were found.

The results of investigations of these objects lead to important conclusions about the luminosity function behaviour for faint UVX galaxies in the region of low and high luminosities and about ELG distribution as a function of redshifts for study of the large scale structure of the Universe as well.

The logarithmic luminosity function for faint galaxies with UV continua of SBS objects is presented in Fig.1.

The luminosity function of UVX galaxies could be extended to 1-1.5 magnitude down to fainter magnitudes in comparison with the First Survey. The completeness of the sample of the UVX galaxies in the Second Survey is 0.5 up to 17^m (Stepanian,1984b).The surface density of UVX galaxies till 18.5 is about two galaxies per square degree.The fraction of Seyfert galaxies among the faint UVX galaxies is more than 10%. The methods of the Second Survey should be successfully used for the selection and investigation of the ELG in the near clusters of galaxies. For example, in the A634 cluster 35 emission line galaxies were discovered (Stepanian, 1984c).

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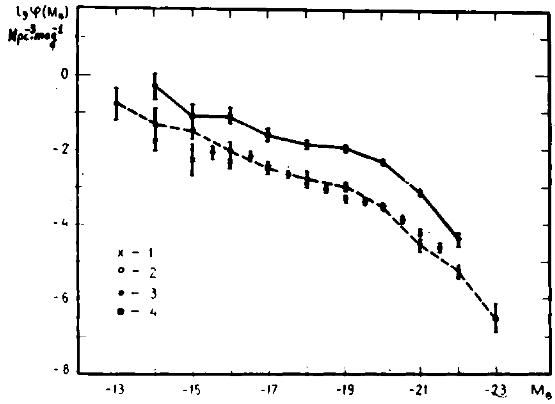

Figure 1. The logarithmic luminosity function of the galaxies with UV-continua as follows: 1-according to Huchra and Sargent (1973); 2-according to Arakelian (1974); 3-our data, Stepanian (1984b) (dashed line); 4-the luminosity function for field galaxies (Huchra and Sargent, 1973) (full line). The vertical bars correspond to σ calculated by formula

$$\sigma = n^{-1/2}.$$

The depth of the selection of ELG increased noticeably (Stepanian, 1985). The surface density of the ELG is more than 4.5 per square degree till 18.5 magnitude.

This estimation is in good agreement with the value, received by Vasilewsky (1983). However, the limiting magnitude of SBS survey on two-three magnitudes exceeds the limiting magnitude of Vasilewsky survey. Our estimate is more than in two times greater than the same estimate of Kitt-Peak Survey and more than an order greater than the estimate of Cerro-Tololo Survey. These questions in more details are discussed in Stepanian (1984a, 1984b, 1984c, 1985).

4. QUASISTELLAR AND STELLAR OBJECTS* IN SBS.

On the same fields 53 QSO candidates and 80 blue stellar objects - BSO - were selected. In Table 3 the results of slit spectroscopy of these objects are presented.

Table 3

QSO candidates and BSO	Number of objects	Number of slit spectra	QSO	Continual objects	Galaxies	Stars
Q S O	53	43	32	2	-	9
B S O	80	49	12	4	7	26

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As one can see from Table 3 more than 70% of QSO candidates are confirmed as QSO's and 25% from BSO's are QSO as well.The remaining ones are mainly the white dwarfs and hot subdwarfs. Six objects in its slit spectra have neither emission nor absorption lines.

Seven stellar objects - the unexpected great number - were turned out to be very condensed absolutely not differing from the stars - starlike galaxies. Such objects were found by Bohuski et al (1978) as well.

Slit spectroscopy of the Cerro-Tololo QSO candidates showed that 80% of detectable lines on low dispersion plates were confirmed on the slit spectra (Lewis et al,1979). Similar situation was observed according to slit spectroscopy of the QSO candidates in Siding-Spring (Savage et al, 1985) Survey. The remainders were the objects with continual spectra, the white dwarfs, hot subdwarfs and different types of blue stars.

So, from the point of view of their results, all the mentioned surveys are rather similar, while they differ from each other by selection methods of QSO candidates.

At present in SBS survey more than 80 QSO and 20 new Seyfert galaxies were discovered.The range of QSO redshifts were 0.2-2.8, apparent magnitude of $16.5 < m_B < 19.5$ and luminosities $-21 > M_B > -29$.

The surface density of QSO in SBS Survey reaches more than one object per square degree till 18.5, that is in good agreement with other similar surveys.However, for the more exact estimate the photometric data are necessary.

The spectra of some QSOs are shown in fig.2.This spectra are taken from Levshakov et al (1986) and Afanas'ev et al (1986). The most interesting object is BALQSO SBS 1401 + 566 with extremely broad absorption lines,observed to the short wavelength side of emission lines L_α and CIVλ 1549. The apparent photographic magnitude of this object is 17-17.5, the redshift is about $z \approx 2.6$.

The distribution of redshifts of QSOs is presented in fig.3: for the Second Survey (SBS), the University of Michigan Survey (UM), QSO's selected by colorimetric methods - PHL, TON, LB, B and radioquasars (PKS). The redshifts data for these objects are taken from (Veron-Cetti and Veron, 1985). The redshifts data of SBS objects are taken from Markarian et,al (1983). The comparison of these distributions according to X^2 criterion showed, that the distribution of redshifts of the Second Survey QSO's is the closest to the distribution for radioquasars. All these distributions showed strong selection effects caused by the methods of the QSO selection.

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* Blue stars were excluded from the examination.As it was expected they turned out to be the white dwarfs and hot subdwarfs.

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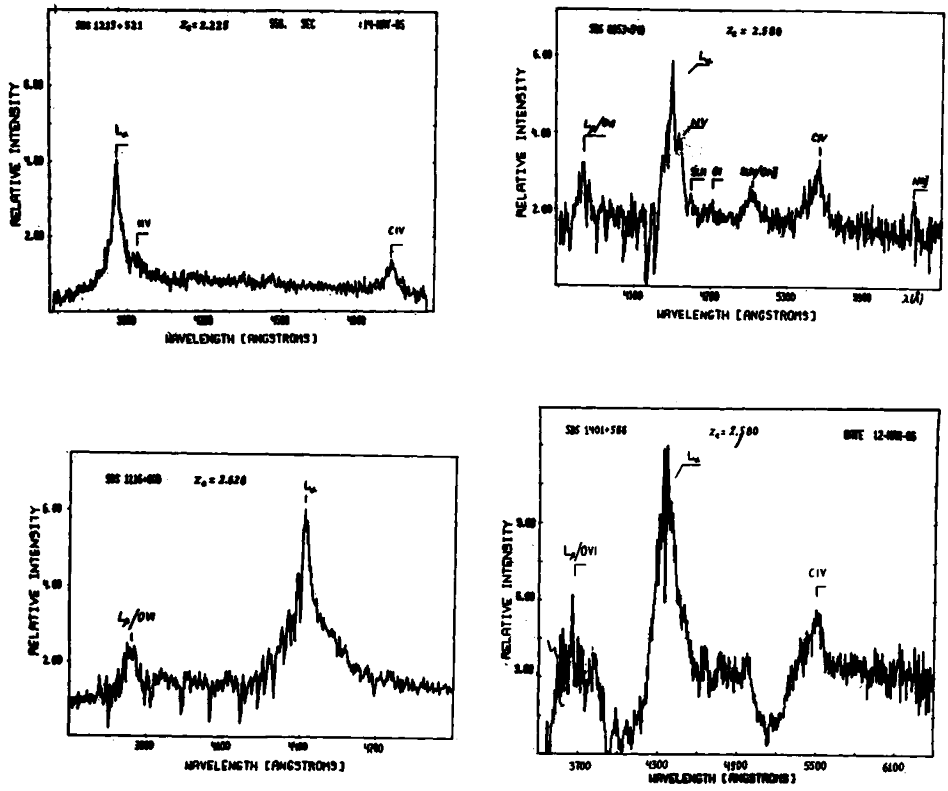

Figure 2. Scanner spectra of individual Qusars from the SBS Survey - SBS 1215+521, SBS 0953+549, SBS 1116+603, and BALQSO SBS 1401+566.

5. CONTINUAL OBJECTS IN SBS SURVEY.

Among the Second Survey objects, except QSOs, the considerable amount of stellar objects was discovered for which the slit spectra obtained with UAGS + Image Tybe in blue region of spectra λλ3600- 5700 have not shown either emission or absorption detectable lines. In our slit spectra we can recognize the lines with equivalent width not less than 3-4 A and the signal to noise radio more than 20%. The list of 33 of such objects were presented in paper (Markarian et al, 1986). The further observations increased the number of the continual objects till 37.

It should be noted, that the similar objects have been marked earlier for the slit spectroscopy of the QSO candidates, selected by colorimetric methods (Sandage, 1965 , Burbidge and Burbidge, 1969). Besides, four objects with continual spectra have been found recently on the slit spe-

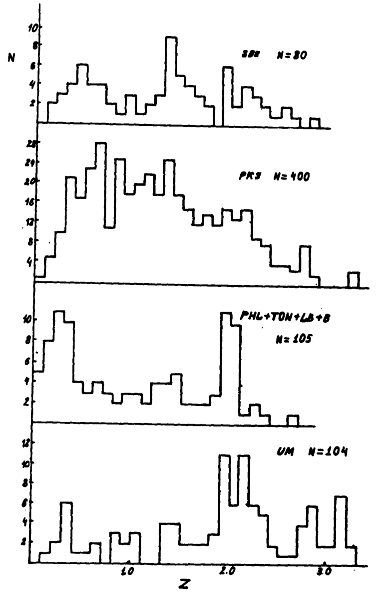

Figure 3. The redshifts distribution of QSOs from different samples.

ctra of the QSO candidates in the Siding-Spring Survey (Savage et al, 1985).

The more significant number of the similar objects were discovered in the SBS Survey and the reason was that we selected the objects by strong ultraviolet continua and by characteristic distribution of energy in continuous spectrum.

The systematic observations of these continual objects were begun with the 6-m telescope with the TV 1000-channel scanner. The threshold of lines detection reaches up to the signal to noise ratio of 5-10%.

Scanner spectra in the region of λλ 3600-5200 for 34 from 37 continual objects were obtained. The results of these observations are presented in Table 4.

Table 4

Number of objects	Number of IPCS spectra	QSO	Continual objects	Stars	Galaxies
37	34	9	10	14	1

The considerable part of these objects - nine objects (26%) - turned out to be QSO with broad marginal emission lines. One object - SBS 1214+554 - was the galaxy with redshift of z=0.175. Ten objects were white dwarfs of the types: DC(1), λ 4670(1), DA(4), DB(4) and four objects were hot subdwarfs. However, the remaining ten objects in the spectral range of λλ 3600-5200 on the scanner spectra had not shown any detectable emission or absorption lines.

The nature of these objects is not clear. They may be either galactic or extragalactic stellar objects. Their apparent magnitudes are 16.5-19.5.

The spectral observations in other ranges of spectra, photometric, polarimetric, radio and other observations are necessary to clear up the nature of these objects. The measurement of the proper motions is desirable. Among these objects can be expected probably the optical lacertides and possibly the objects of other nature.

6. RADIOFIELD 5C1. INVESTIGATIONS OF BLUE OBJECTS.

Radiofield 5C1 has some overlap with the region of the SBS Survey. In this field there is a photometry of blue objects, which has been carried out by Notni (1980). Our fields overlap over eight square degrees. Notni used the following criterion for the selection of blue objects U-B $<$ $-0^m.2$. At all 85 Notni's objects were got in the common field. The investigation of the blue objects selected by Notni by its color, showed that only the objects which have U-B $<$ $-0^m.5$ showed the UV-excess on our low dispersion plates.

In this common field we selected 27 objects from Notni's list, restricting the sample of Notni by objects with limiting magnitude m $<$ 19.0 and by color U-B $<$ -0.5. The scanner spectra with the 6-m telescope of the Special Astrophysical Observatory have been obtained for 24 of them.

The distribution of objects according to its type are presented in Table 5.

Table 5

Sample	Number of objects	Number of spectra	QSO	Continual objects	Gala-xies	White dwarfs
Notni	27	24	8	3	1	12
SBS	8	5	1	3	-	1

As one can see from Table 5, from the objects selected for color U-B $<$ $-0^m.5$ only 33% are QSO. Half of them - 50% are white dwarfs of different types. Three objects in their scanner spectra showed neither detectable absorption nor emission lines. One stellar object - Notni 119 - was the galaxy with redshift z = 0.19. In the same field besi-

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de 27 blue objects from Notni list, we found also eight blue objects on our objective prism plates too.

Their distributions of detectable types after scanner's observations are presented in the second line of Table 5.

So, even by careful selection of objects, based on colorimetric methods only, the definite number of the objects was missed.

This investigation shows that only 30-40% of the objects having U-B < $-0^m.75$ are real QSOs. The low dispersion methods for selection of QSOs show the higher level of the discovery independently from the objects color. But all these methods suffer from considerable incompleteness. It is obvious, that the most complete QSO sample can be obtained by the analysis of the whole spectrum by combination with other methods of selection of the objects.

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DISCUSSION

LORENZ: Do you have ideas about the nature of the remaining objects in the Notni - list concerning to the colour interval -0.2 to -0.5?

STEPANIAN: Observations of Notni's objects which have -0.2 >U-B> -0.5, will possibly be continued.

MARASCHI: Could the continuum objectsthat you discovered in the SBS be new BL LAC candidates?

STEPANIAN: Yes, of course it may be. It is necessary to make photometric, polarimetric, radio and other observations to clear up the nature of this object.

TSVETANOV: You showed us a LF of galaxies with UV excess. May we think that the UV galaxies present a constant part of field galaxies all over the whole region of absolute magnitudes from -16 to -23^m, and what is the percentage of them?

STEPANIAN: UV galaxies presented approximately a constant part of field galaxies in all regions of absolute magnitudes from -16^m to -23^m, and consist about 8% of them.

MELNICK: The spectra of QSO's you showed are very nice. Could you give us some more details about the instrumentation used at the 6m telescope to get these spectra?

STEPANIAN: The spectra of QSO's we obtained with the TV 1000-channel Photon Counting System of 6m telescope.

KOMBERG: How is the percentage of different types of objects changed in connection with its redshifts?

STEPANIAN: It is a difficult question. Let us return to it in private.

RUBIN: Was each field observed in all 3 colours? I would be interested in the search procedures and the statistics of detection on the 3 colours.

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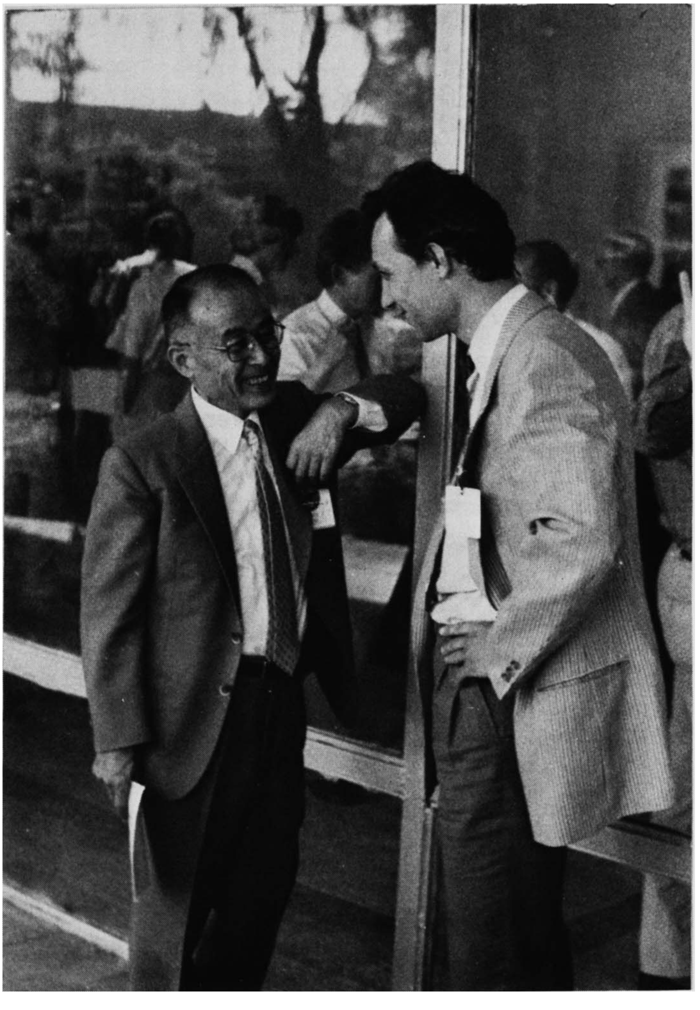
STEPANIAN: Our observational method differs from others by application besides 1°5 prism, 3° and 4° degrees prism, and the presence of red region. Furthermore the selection of objects we made by presence of emission lines in red and in blue regions, and by characteristic distribution of energy in continuous spectrum. Each field we observed in all three colours:

a) Blue and UV region - IIIaI + 1°5 prism
b) Green region - IIIaI + GG495 + 3° prism
c) Red region - IIIaF + RG2 + 4°prism

For the selection of QSO, BSO, BS and UVX galaxies the main region is the region of λλ3500-5350-IIIaI + 1°5. In the red region we select the ELG with $z \leqq 0.04$, and we used this region for the confirmation of the emission lines in QSO's detected in blue region. Moreover, when we detected in the spectra of galaxies the emission lines in red region (Hα,SII), we checked up the presence of emission lines in green region (N1,Hβ) and after that we may have to estimate the redshift of these objects. In green region we selected ELG with redshift $0.1 \geqq z > 0.04$ and we used this region for the separate ELG with $z \leqq 0.1$, from the QSO's of high redshift $z > 2.8$. So, the red region is very important for the selection of ELG. The investigation showed, that more than 50% of ELG were selected in red region. Surveys which are not using the Hα region for selection of ELG missed significant part of ELG. This is in the main low excitation ELG.

GORBATSKY: What is the difference between probable candidates for QSO and possible candidates for QSO?

STEPANIAN: The objects having emission lines are probable candidates for QSO and objects with different stellar like spectra (continous) are possible candidates.



Takase and Tsvetanov during a break