THE SECOND BYURAKAN SURVEY

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ABSTRACT. On the basis of the Second Byurakan Survey (SBS), we have produced a new complete sample of bright QSOs.

The observations were obtained using the 1.5, 3 and 4 degree objective prisms with the 40-52 inch Schmidt telescope at the Byurakan Observatory. The total sky coverage area of SBS is 1000 square degrees from R.A. 07h40m - 17h15m and Dec. +49 - +61.

In all, in SBS about 3000 – 1600 stellar objects have been selected, and about 1400 galaxies down to a limiting magnitude B ~ 19.5.

290 QSO and 67 Sy galaxies are spectroscopically confirmed.

The estimate of surface density of SBS QSOs in the magnitude range 15.5 < B < 17.2 and redshift distribution of SBS QSOs and Sy galaxies are given.

1. Introduction

Wide-field sky surveys have proved essential tools for statistical astronomy, based mainly on Schmidt photographic plate surveys. In the last 30 years, from the discovery of the quasars by M. Schmidt, a large army of astronomers all over the world have discovered about 6500 QSOs. Practically all telescopes in the world have been used for searching the QSOs. Now the deepest QSO survey has reached up to the 23 mag, the most distant QSO has a redshift of z = 4.897.

Up to 1985 the QSOs with highest redshift were discovered using radio surveys; from 1985 until now the highest redshift QSOs were discovered only from optical surveys.

Nevertheless, of 6500 QSOs discovered today, the number of bright QSOs are only a few hundred, complete samples contain only a few dozen. The total number of bright QSOs which is available from statistics from complete samples consists of about ~ 100 objects brighter than B < 17.0, and ~ 200 objects brighter than B < 17.5.

The SBS survey contains ~ 60 new QSOs brighter than B < 17.0 and ~ 140 new QSOs brighter than B < 17.5, so more than 50% of all known bright QSOs (complete samples) will be added from the SBS survey.

In order to get a better understanding of the physics, evolution and spacetime distribution of QSOs, it is still necessary to increase the number of known objects, especially bright QSOs. Several projects aimed at mapping large fractions of the sky or even the whole sky are now under way.

H. T. MacGillivray et al. (eds.), Astronomy from Wide-Field Imaging, 731–736.

2. The Second Byurakan Survey

The first complete sample of AGN was produced from the Markarian survey (Markarian 1967), who first used a thin objective prism for the selection of peculiar extragalactic objects. Now this survey has the name FBS (the First Byurakan Survey). Ten years later a similar survey was begun in Cerro-Tololo (Smith 1976), while grism observations were made at KPNO in 1970 (Hoag 1970).

The Second Byurakan objective prism survey started in 1974 and finished in 1991. A first list of SBS objects was published in 1983 (Markarian & Stepanian 1983). In total, we have published seven lists (Markarian & Stepanian 1984; Markarian, Stepanian & Erastova 1985, 1986; Stepanian, Lipovetsky & Erastova 1988, 1990). SBS is the continuation of the Markarian survey to fainter magnitude.

The observations were obtained using a 1.5, 3 and 4 degree objective prism with the 40–52 inch Schmidt telescope at the Byurakan observatory. The method of selection was visual, i.e. scanned by eye. The criteria of selection: strong UV continuum, emission lines, energy distribution in the spectra.

Here, we briefly describe the SBS survey, which is now practically finished.

Second Byurakan Survey
General description

Name of survey	Telescope	Field of view (deg)	Detector		Disper. A/mm	Wavelength	Number of field
SBS	40" Byurakan Schmidt	4.1 x 4.1	IIIa-J+	1.5 prism	1800 Hg	3500-5400	65
			IIIa-J+GG495	+3 prism	800 Hg	4950-5400	10
			IIIa-F+RG2	+4 prism	1000 Ha	6300-6950	50

Beginning of survey		1974	Markarian, Stepanian
Publication: list	1-3 (3 fields)	1983-1984	Markarian, Stepanian
	4-5 (2 fields)	1985-1986	Markarian, Stepanian, Erastova
	6-7 (2 fields)	1988-1990	Stepanian, Erastova, Lipovetsky
Unpublished data	(58 fields)	1988-1993	Stepanian, Erastova, Chavushian, Balaian

Completion of observations and search	1991
Spectral observations	1977 – continued
Continuation of survey	1974 – 1991
Publication of catalogue	– planned in 1994
General data	500 plates; 65 fields; survey complete ~ 17.5; scanned by eye ~ 80 million spectral images

Region of sky	R.A. 07 40-17 15, Dec. +49 00-61 00
Limiting magnitude m(pg)	~ 19.5
Total area (sq, deg)	~ 1000
Total number of objects	~ 3000; stellar objects: ~ 1600 non stellar objects: ~ 1400

Present status slit spectra:		~ 1700 (~50%)	
(1993)	Stellar objects:	~ 1100 (~70%);	QSOs - 290
			stars - 810
	Nonstellar objects:	~ 600 (~45%)	Sy galaxies 67, BCDG ~ 150
			Other types of galaxies ~ 380
	Photometry:	~ 120 (~ 4%)	QSOs ~ 90, Galaxies ~ 30

Main goal:
— to expand Markarian survey as deep as possible
— to produce a complete sample of bright QSOs in the mag. range 15.5 - 17.5
— to produce a complete sample of faint Markarian galaxies in the mag. range 15.5 - 17.5
— to study the large-scale structure of the Metagalaxy, large-scale distribution of QSOs, faint Markarian galaxies, and other types of selected objects, clustering of QSOs, etc.

Results of spectral observations

m(pg) mag.	N total	N obs.	N not obs.	N (QSO) total	z < 2.2	z > 2.2
< 16.0	188	188	-	6	6	-
< 16.5	332	332	-	18	18	-
< 17.0	548	540	8	60	56	4
< 17.5	842	710	132	136	125	11
< 19.5	1600	1100	500	290	259	31

In Table 1 we collected together the data for a few bright quasar surveys. Some of these are finished, they are well known (BQS, LBQS), others now continuing (MBQS, CASE), while others are the new surveys (EMS, HQS).

As a rule most surveys are aimed at producing complete samples of QSOs in the investigated areas, which are limited by magnitude or by area.

It can be seen that there is a big lack between BQS and other surveys, by investigated area as well as by limiting mag. Up to now it has been necessary to have a survey with the area coverage of about three or four thousand square degrees, and limiting magnitude about 18.0 – 18.5.

Table 1. Bright quasar surveys

Name	Date	Tel. Site	Type	Method	Criteria	Objects
SBS	1974-1991	40" Byurakan	Spectral	Prism Visual	UVX, Em.	QSO, UVG
CASE	1983-cont.	24" BS KPNO	Spectral	Prism Visual	UVX, Em.	QSO, UVG
LBQS	1987-1991	48" UKST	Spectral	Prism Auto.	UVX, Em.	QSO
HQS	1990-cont.	31" Cal-Alto	Spectral	Prism Auto.	UVX, Em.	QSO
BQS	1973-1983	18" Palomar	Photom.	UB Visual	Two-Col.	QSO, BS
MBQS	1981-cont.	48" Palomar	Photom.	UBV Visual	Three-Col.	BS
EMS	1991-cont.	48" UKST	Photom.	UBVRI Auto.	Multi-Col.	QSO

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Table 1 cont. Comparative characteristics

Name	Area (deg)	m(compl)	N(QSO)	z(max)	Authors
BQS	10714	16.12	92	2.2	Schmidt & Green 1983
EMS	330	16.5	8	1.3:	Goldschmidt et al. 1992
SBS	1000	17.2:	120:	3.2	Stepanian (this work)
MBQS	108.6	17.65	32	2.2	Mitchell et al. 1984
LBQS	453.8	18.41	997	3.4	Foftz et al. 1993

In the middle of the 70s we undertook the SBS survey. Unfortunately because of different reasons SBS was stopped in 1991, and we were able to investigate only about ~ 1000 sq. deg. Now the pretender of such type of survey remains in the form of CASE, EMS and HQS.

Table 2. Surface density of bright QSOs*

B	BQS		EMS		MBQS		LBQS		SBS	
	n	d	n	d	n	d	n	d	n	d
<15.0	11	0.0010								
<15.2	18	0.0017								
<15.4	23	0.0021	-	-					1	0.001
<15.5			1	0.003	-	-			2	0.002
<15.6	35	0.0033	2	0.006	1	0.0092	-	-	2	0.002
<15.8	36	0.0036	3	0.009	1	0.0092	-	-	4	0.004
<16.0	44	0.0054	4	0.012	1	0.0092	1	0.0022	6	0.006
<16.2	26	0.0068	6	0.018	2	0.0184	2	0.0044	9	0.009
<16.4	8	0.014	8	0.024	4	0.0368	3	0.0066	15	0.015
<16.5			9:	0.027:	5	0.0460	3	0.0066	20	0.020
<16.6					7	0.0644	4	0.0088	24	0.024
<16.8					9	0.0828	8	0.0177	38	0.038
<17.0					11	0.101	18	0.040	57	0.057
<17.2					13	0.120	32	0.070	75	0.075

*) $M(B) \leq 23$ ($H = 50$ km/s Mpc, $q(0) = 0$, $z < 2.2$) $d = n(< B)$ deg-2

3. Results

In total in the SBS we discovered 290 QSOs and 67 Sy galaxies. In Fig. 2 we give the redshift distribution of SBS QSOs and Sy galaxies. We predict that the complete sample of SBS QSOs will be nearly $B < 17.5$ magnitude.

Spectroscopy are available for 99% and 85% for objects brighter than $B < 17.0$, and $B < 17.5$ respectively. Photometry is available for about 70%, and 50% for objects brighter than $B < 17.0$ and $B < 17.5$ respectively. It can be seen from Table 2 that up to the:

$B < 15.5$ — BQS has no competitor, it is the most powerful survey;

$B < 16.0$ — if the result of Goldschmidt et al. (1992) will be confirmed in a big area, aimed at increasing the number of objects, then BQS and as well as SBS may be incomplete by a factor of 2;

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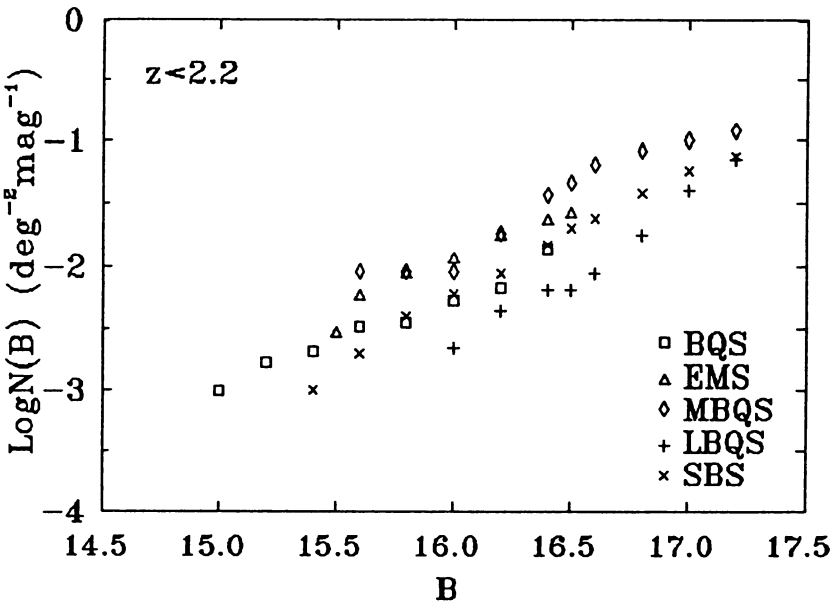

Figure 1. The number magnitude relation of SBS QSOs.

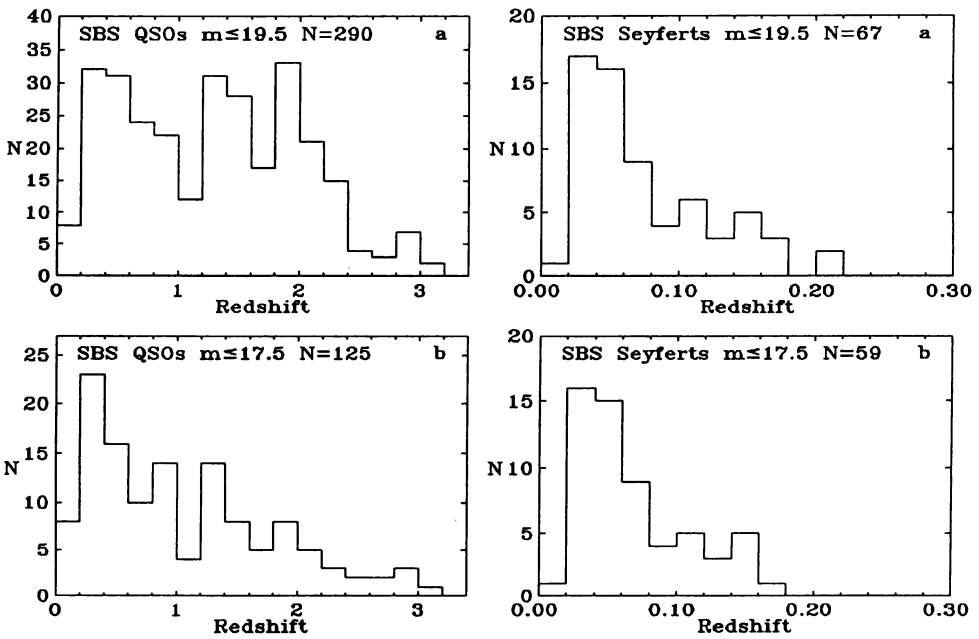

Figure 2. Redshift distribution of SBS QSOs and Sy galaxies a) full sample, b) complete sample.

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B < 16.5 — SBS results are much lower than MBQS data (MBQS result is too high but the number of objects too small), but close to EMS data. We estimate the SBS incompleteness to be no more than a factor of 1.5;
B < 17.0 — SBS gives the certain lowest limit to surface density.

4. Conclusion

— SBS is the largest continuous quasar survey with B < 17.5;
— SBS provides a new complete sample of bright QSOs in mag range 16.5 - 17.5 and may fill this interval of magnitudes;
— SBS adds more than 50% of all known QSO in mag range 16.5 - 17.5 available for statistics;
— SBS significantly expands the number of QSOs suitable for high dispersion investigations.

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