АСТРОФИЗИКА

ТОМ 42 ФЕВРАЛЬ, 1999 ВЫПУСК 1

УДК: 524.354.6:539.12

ON THE NATURE OF THE FBS BLUE STELLAR OBJECTS AND THE COMPLETENESS OF THE BRIGHT QUASAR SURVEY*

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Received 15 September 1998
Accepted 15 November 1998

The second part of the First Byurakan Survey is aimed at detecting all bright (B < 16.5) UV-excess starlike objects in a large area of the sky. By comparison with other major surveys such as the ROSAT All Sky Survey, the ROSAT WGACAT catalogue of point sources, the IRAS survey, the 6cm Green Bank, the 1.4GHz NRAO VLA and the 92cm Westerbork Northern sky surveys and with the catalogue of mean *UBV* data on stars, we estimate the number of AGNs present in the FBS survey and its completeness. We have made spectroscopic observations of nine of the most promising FBS candidates. We have found six new QSOs bringing the total number of known QSOs in this survey to 42. By comparison with the Bright Quasar Survey, we found that the completeness of this last survey is of the order of 70% rather than 30-50% as suggested by several authors.

1. *Introduction.* The surface density of bright QSOs (B < 17.0) is still very poorly known. The Palomar Green (PG) or Bright Quasar Survey (BQS) [1,2] covering an area of 10714 deg^2 lead to the discovery of 69 QSOs brighter than M_B = -24 (H_0 = 50 km s^{-1} Mpc^{-1}) and B = 16.16 corresponding to 0.0064 deg^{-2}. However several authors [3-7] suggested that this survey could be incomplete by a factor 2 to 3.

The First Byurakan Survey (FBS), also known as the Markarian survey, was carried out in 1965-80 by Markarian et al. [8]. It is a slitless spectroscopic photographic survey carried out with the 40' Schmidt telescope of the Byurakan Observatory. The 1.5° prism used gave a reciprocal dispersion of 1800 A/mm at H_γ. Each field is 4° x 4° in size. The survey is about 17000 deg^2 and is complete to about $B = 16.5^m$. It has been used by Markarian and his collaborators to search for UV excess galaxies; more than 1500 have been found, including about 10% Seyfert galaxies and a few QSOs. It can also be used for finding UV excess

* *Partly based on observations collected at the Observatoire de Haute Provence (CNRS, France).*

The APS databases are supported by the National Science Foundation, the National Aeronautics and Space Administration, and the University of Minnesota, and are available at http://aps.umn.edu/

The Digitized Sky Survey was produced at the Space Telescope Science Institute (STScI) under U.S.Government grant NAG W-2166.

or emission line starlike objects. Such a program - the second part of the FBS - has been undertaken in 1987 [9,10]. Its main purpose is to take advantage of the large area covered to get a reliable estimate of the surface density for bright QSOs. The discovery of a number of planetary nebula nuclei, white dwarfs, cataclysmic variables and other UV excess objects is also expected.

2. *The FBS Survey.* At the present time, 4109 deg² have been searched ($33° < \delta < 45°$ and $\delta > 61°$, excluding the Galactic plane) and a catalogue of 1103 blue stellar objects has been built. It has been published in a series of eleven papers [9,11-20]. It contains 388 objects at $|b| < 30°$, including 33 at $12° < |b| < 15°$. Fig.1 shows the distribution on the sky of the 1103 objects.

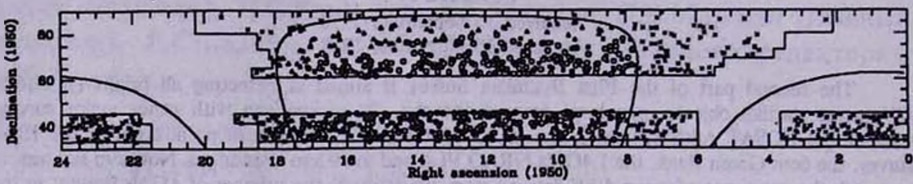

Fig.1. Sky map of the FBS objects. Lines of constant galactic latitudes are indicated ($b = 0°$ and $b = 30°$). The nominal limits of the FBS are shown. Crosses are for objects at $|b| < 30°$, triangles for objects at $b > 30°$ but outside the PG area, filled squares for objects detected by the PG survey and open circles for objects within the PG area, but undetected.

433 spectroscopic identifications (397 stars and 36 QSOs) are already known, taken mainly from [21-34], catalogues of spectroscopically identified white dwarfs [35,36], the catalogue of cataclysmic variables [37] and the catalogue of subdwarfs [38].

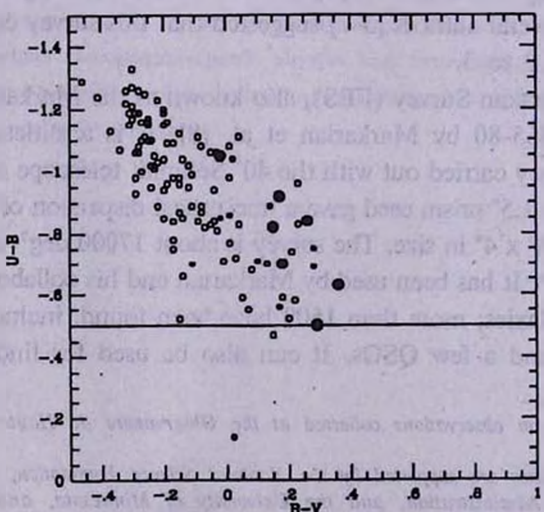

Fig.2. Plot of $U - B$ vs. $B - V$ for the FBS objects with published photoelectric measurements. Open circles are for B type objects, small dots for N types and large dots for QSOs.

106 FBS stars have published UBV colours [1,39] as well as seven FBS QSOs [26]. With the exception of FBS 1002+390 ($U - B = -0.14$ [40]), they all have $U - B < -0.50$ (Fig.2). The FBS objects have been classified as B or N according to the ratio of the intensity of the red and blue regions of the spectra. The catalogue contains 862 B objects, 233 N and 8 others. According to the classification, in general B objects should have a negative $B - V$, while N objects should have a positive $B - V$ [9]. In fact, if most N objects have a positive $B - V$, a significant fraction of the B objects also have a positive $B - V$ (Fig.2).

Sixteen QSOs are of B type or 1.8% of all B type objects, while 20 are of N type or 8.5% of all N type; N type objects are therefore much more likely to be QSOs which however have about the same probability to be of N or B type. Nevertheless, among the eight FBS QSOs with $z > 1$, seven are of N type, while only one is of B type.

The positional accuracy for the first 429 objects (first four papers) is quoted as being about one arcmin. Later the accuracy was increased to 0.5' [11]. An accurate optical position has been measured for 195 objects on the Digitized Sky Survey; the accuracy is ~0.6" [41]. These positions are given in Table 1. We have compared the published FBS positions with sub-arcsecond accuracy positions for 104 objects of the first four papers and 117 objects of the last seven papers. After correcting for printing errors in the published position of FBS 0649+716, 0935+416, 1559+369 and 1619+648, we found $\sigma_\alpha = 46''$, $\sigma_\delta = 40''$ and $\sigma_\alpha = 9''$, $\sigma_\delta = 7''$ respectively; these errors are substantially smaller than the initial estimates.

The magnitudes of the objects in the first four papers have been measured from the O Palomar Sky Survey prints, using the relationship between stellar diameters and magnitudes established by [42]; however in these papers, the PG magnitude, when available, was given rather than the FBS magnitude. In contrast, for the objects listed in the last seven papers, the magnitudes have been measured on both the O and E prints, with the calibration given by [43] and the V magnitude computed with the formula: $V = E - (O - E)/3.2$. The photometric accuracy which was thought to be $0^m.5$ in the first series of measurements was improved to $0^m.3$ starting with the fifth paper [11].

Comparison of the FBS and photoelectric V magnitudes for the objects in the last seven papers gives $\langle FBS - V \rangle = 0^m.06$ and $\sigma = 0^m.46$. For 29 objects from the first four papers, we have $\langle FBS - V \rangle = -0^m.40$, $\sigma = 0^m.75$. This confirms the significant improvement of the photometric accuracy achieved in the second part of the catalogue. However, the accuracy seems to be $0^m.75$ and $0^m.45$ in the first and second part respectively, rather than the estimated $0^m.5$ and $0^m.3$.

3. *Comparison with X-ray, infrared and radio surveys.* 3.1. *The ROSAT All-Sky Survey Bright Source Catalogue (RASS-BSC).* We have cross-correlated our list of 1103 UV-excess objects with the

Table 1

ACCURATE POSITIONS FOR 195 FBS OBJECTS

Name	α (B1950)	δ (B1950)	Name	α (B1950)	δ (B1950)
1	2		3	4	
FBS 0004+330	$00^h 04^m 57^s 58$	$33° 00' 49'' 2$	FBS 0808+435	08 08 05.06	43 32 13.8
FBS 0019+348	00 19 10.52	34 48 13.3	FBS 0808+628	08 08 05.58	62 45 24.2
FBS 0019+401	00 19 44.22	40 09 12.4	FBS 0819+364	08 19 32.57	36 23 54.1
FBS 0028+441	00 28 01.72	44 07 59.3	FBS 0821+676	08 21 33.89	67 37 07.7
FBS 0028+435	00 28 53.76	43 32 32.1	FBS 0827+738	08 27 10.40	73 47 17.6
FBS 0038+431	00 38 10.80	43 08 32.7	FBS 0836+619	08 36 33.96	61 58 32.2
FBS 0043+343	00 43 09.54	34 18 11.0	FBS 0845+812	08 45 25.59	81 10 16.7
FBS 0047+347	00 47 14.22	34 41 52.7	FBS 0848+437	08 48 22.96	43 45 22.7
FBS 0051+417	00 51 36.77	41 47 08.8	FBS 0850+639	08 50 37.98	63 54 46.1
FBS 0058+431	00 58 18.96	43 07 17.9	FBS 0904+643	09 04 58.96	64 22 06.4
FBS 0125+351	01 25 14.97	35 06 10.5	FBS 0906+368	09 06 18.10	36 49 46.8
FBS 0125+386	01 25 35.36	38 39 07.4	FBS 0914+656	09 14 51.16	65 36 45.7
FBS 0127+408	01 27 00.52	40 47 19.5	FBS 0920+674	09 20 01.27	67 23 05.9
FBS 0140+427	01 39 59.78	42 42 14.6	FBS 0920+366	09 20 49.65	36 36 35.2
FBS 0150+396	01 50 6.88	39 41 00.0	FBS 0924+732	09 24 23.00	73 09 46.9
FBS 0154+391	01 54 18.51	39 08 25.2	FBS 0926+850	09 26 34.50	85 01 39.0
FBS 0156+439	01 56 40.53	43 58 47.4	FBS 0929+733	09 29 12.25	73 16 16.2
FBS 0212+385	02 12 55.08	38 32 26.6	FBS 0932+437	09 32 12.72	43 44 31.0
FBS 0217+343	02 17 17.08	34 20 00.4	FBS 0933+614	09 33 53.15	61 25 18.0
FBS 0228+447	02 28 42.59	44 44 13.1	FBS 0935+679	09 35 18.71	67 54 00.8
FBS 0233+373	02 33 37.67	37 21 17.7	FBS 0935+395	09 35 42.66	39 32 25.3
FBS 0255+379	02 55 30.67	37 57 40.1	FBS 0938+374	09 38 24.45	37 26 03.6
FBS 0306+333	03 06 07.77	33 20 01.4	FBS 0938+447	09 38 34.70	44 42 46.2
FBS 0315+417	03 15 04.13	41 44 27.0	FBS 0941+664	09 41 18.63	66 25 20.8
FBS 0421+740	04 21 26.14	74 00 46.2	FBS 0944+713	09 44 45.41	71 15 09.4
FBS 0432+763	04 32 27.59	76 18 44.6	FBS 0950+664	09 50 09.49	66 22 30.9
FBS 0437+756	04 37 51.88	75 33 21.5	FBS 0953+686	09 53 03.57	68 36 35.8
FBS 0613+431	06 13 06.93	43 10 59.2	FBS 0954+697	09 54 24.61	69 43 20.5
FBS 0614+769	06 14 01.33	76 52 53.3	FBS 0958+353	09 58 17.44	35 19 37.2
FBS 0624+428	06 24 17.31	42 48 39.1	FBS 1002+437	10 02 37.27	43 47 17.2
FBS 0632+663	06 32 03.44	66 15 21.6	FBS 1003+678	10 03 08.82	67 47 25.6
FBS 0637+786	06 37 33.69	78 38 04.1	FBS 1007+382	10 08 04.69	38 16 48.9
FBS 0639+391	06 39 14.98	39 11 22.0	FBS 1040+451	10 40 36.64	45 09 14.0
FBS 0649+716	06 49 08.05	71 37 22.5	FBS 1054+436	10 54 35.66	43 37 10.6
FBS 0652+799	06 52 50.66	79 55 54.5	FBS 1057+719	10 57 07.54	71 54 10.6
FBS 0654+366	06 54 40.40	36 34 23.4	FBS 1102+347	11 02 54.97	34 41 47.0
FBS 0702+616	07 02 14.87	61 38 29.6	FBS 1103+385	11 03 04.38	38 29 16.9
FBS 0706+407	07 06 42.65	40 41 18.2	FBS 1104+408	11 04 54.15	40 49 08.5
FBS 0716+365	07 16 52.62	36 29 01.9	FBS 1108+402	11 08 10.48	40 15 35.6
FBS 0732+396	07 32 58.96	39 32 59.4	FBS 1112+668	11 12 19.28	66 48 23.4
FBS 0742+653	07 42 41.23	65 20 24.7	FBS 1122+426	11 22 09.44	42 41 53.7
FBS 0742+337	07 42 59.53	33 40 29.4	FBS 1125+634	11 25 45.85	63 21 16.2
FBS 0744+818	07 44 27.07	81 49 30.3	FBS 1129+823	11 29 34.93	82 19 40.7
FBS 0744+652	07 44 52.30	65 10 16.2	FBS 1133+754	11 33 32.66	75 23 30.2
FBS 0747+729	07 47 53.47	72 57 44.2	FBS 1138+648A	11 38 45.38	64 49 08.6
FBS 0749+725	07 49 44.82	72 32 17.9	FBS 1138+648B	11 38 46.11	64 49 12.1
FBS 0752+769	07 52 40.64	76 54 28.6	FBS 1139+437	11 39 35.91	43 40 54.9

Table 1 (окончание)

1	2	3	4
FBS 1140+719	11 40 48.57 71 57 58.5	FBS 1554+403	15 54 04.46 40 20 24.6
FBS 1141+406	11 41 40.55 40 41 08.0	FBS 1557+448	15 57 08.98 44 49 30.8
FBS 1147+673	11 47 46.03 67 15 28.5	FBS 1559+369	15 59 32.42 36 57 20.2
FBS 1148+444	11 48 47.18 44 29 23.1	FBS 1602+408	16 02 43.08 40 49 06.3
FBS 1149+394	11 49 27.95 39 25 08.7	FBS 1603+369	16 03 43.62 36 57 42.3
FBS 1150+334	11 50 16.53 33 23 59.8	FBS 1605+684	16 05 29.76 68 22 07.7
FBS 1156+432	11 56 13.19 43 15 48.2	FBS 1605+627	16 05 47.96 62 40 55.8
FBS 1201+437	12 01 51.15 43 47 39.3	FBS 1607+439	16 07 53.88 43 54 10.5
FBS 1211+393	12 11 04.32 39 17 34.8	FBS 1619+749	16 19 47.45 74 55 38.0
FBS 1223+665	12 23 13.26 66 31 26.9	FBS 1619+648	16 19 55.70 64 43 01.2
FBS 1229+383	12 29 03.27 38 19 15.0	FBS 1634+706	16 34 51.56 70 37 37.5
FBS 1229+710	12 29 28.28 71 00 47.2	FBS 1636+351	16 36 36.52 35 06 03.8
FBS 1230+417	12 30 00.95 41 45 51.3	FBS 1638+388	16 38 34.72 38 48 04.0
FBS 1231+828	12 31 46.59 82 50 21.8	FBS 1640+362	16 40 08.90 36 09 43.2
FBS 1232+379	12 32 28.31 37 54 14.5	FBS 1641+399	16 41 17.55 39 54 10.7
FBS 1235+699	12 35 12.88 69 58 13.2	FBS 1641+388	16 41 18.89 38 46 42.4
FBS 1240+631	12 40 27.96 63 06 21.5	FBS 1648+371	16 48 22.63 37 06 16.4
FBS 1248+374	12 48 44.76 37 23 00.3	FBS 1648+407	16 48 40.95 40 42 25.3
FBS 1249+433	12 49 48.58 43 20 24.5	FBS 1656+354	16 56 01.70 35 25 05.1
FBS 1255+447	12 55 01.75 44 45 46.8	FBS 1657+344	16 57 01.28 34 23 23.1
FBS 1311+664	13 11 50.12 66 27 01.9	FBS 1658+440	16 58 17.09 44 05 23.6
FBS 1315+645	13 15 09.88 64 31 09.8	FBS 1715+406	17 15 38.48 40 37 55.0
FBS 1315+447	13 15 49.63 44 43 19.5	FBS 1715+424	17 15 45.05 42 29 18.8
FBS 1316+446	13 16 01.31 44 40 06.0	FBS 1716+394	17 16 22.39 39 19 49.3
FBS 1324+448	13 24 54.58 44 50 36.4	FBS 1722+356	17 22 48.91 35 36 55.3
FBS 1335+369	13 35 38.77 36 52 50.6	FBS 1743+440	17 43 26.45 44 05 51.0
FBS 1338+666	13 38 03.38 66 35 50.6	FBS 1745+420	17 44 55.66 42 04 44.0
FBS 1340+813	13 40 40.59 81 18 10.8	FBS 1755+663	17 55 41.53 66 19 16.4
FBS 1351+640	13 51 46.29 64 00 29.0	FBS 1756+394	17 55 55.40 39 21 14.2
FBS 1352+386	13 52 26.75 38 39 18.4	FBS 1756+441	17 56 11.82 44 11 07.8
FBS 1352+451	13 52 49.55 45 08 13.9	FBS 1756+352	17 56 30.04 35 09 17.3
FBS 1356+389	13 56 24.73 38 58 27.6	FBS 1800+686	18 00 26.61 68 35 56.0
FBS 1359+411	13 59 12.50 41 09 01.9	FBS 1810+374	18 10 39.33 37 24 40.4
FBS 1401+865	14 01 11.14 86 29 42.8	FBS 1815+381	18 15 39.96 38 09 43.1
FBS 1402+436	14 02 37.67 43 41 26.9	FBS 1820+809	18 20 54.40 80 54 13.7
FBS 1413+757	14 13 08.72 75 40 15.8	FBS 1821+643	18 21 36.76 64 20 18.7
FBS 1429+373	14 29 54.34 37 19 41.7	FBS 1822+352	18 22 21.32 35 14 38.3
FBS 1437+398	14 37 18.97 39 49 35.3	FBS 1822+414	18 22 21.69 41 27 33.2
FBS 1440+753	14 40 14.76 75 18 20.0	FBS 1833+447	18 33 25.29 44 45 48.6
FBS 1444+637	14 44 57.08 63 41 53.2	FBS 1833+434	18 33 45.70 43 25 00.7
FBS 1449+440	14 49 36.48 44 06 03.6	FBS 2149+425	21 49 04.38 42 32 39.1
FBS 1449+642	14 49 37.67 64 15 46.8	FBS 2152+408	21 52 47.31 40 49 58.0
FBS 1452+762	14 52 16.36 76 12 10.1	FBS 2212+421	22 12 29.04 42 08 08.5
FBS 1500+752	15 00 43.03 75 10 33.1	FBS 2246+414	22 47 00.80 41 28 01.1
FBS 1501+664	15 01 24.25 66 24 01.4	FBS 2248+446	22 48 19.36 44 41 14.5
FBS 1513+442	15 13 02.08 44 12 40.7	FBS 2249+391	22 49 45.92 39 05 20.2
FBS 1522+663	15 22 16.88 66 15 31.0	FBS 2302+427	23 02 43.64 42 46 33.8
FBS 1523+363	15 23 16.94 36 15 38.0	FBS 2308+425	23 08 26.99 42 33 51.2
FBS 1534+389	15 34 32.03 38 55 52.6	FBS 2315+443	23 15 48.38 44 20 01.2
FBS 1539+355	15 36 02.86 35 28 08.8	FBS 2340+422	23 40 54.17 42 17 39.9
FBS 1551+719	15 51 40.69 71 54 05.0		

ROSAT All-Sky Survey bright source catalogue [44]. There are 2225 X-ray sources in the area of interest. We have found 57 X-ray sources within 4' of a FBS source, while we expected eight chance coincidences. Therefore most of them are probably real associations. We have measured the accurate optical position of the 33 non-QSO coincidences (Table 1); the differences between the X-ray and accurate optical positions are smaller than 40" except for eight objects, confirming the reality of the associations.

The source RX J17173+4227 which is associated with the radiosource B3 1715+425 has been identified with the Zwicky cluster of galaxies Zw 8193 at z = 0.183 [45]; the X-ray and radio positions are in good agreement within the error

Table 2

FBS COINCIDENCES WITH ROSAT AND VLA SOURCES

FBS name	Mag.	O	Catalogue	(1)	(2)	Catalogue	*b*		*z*
0732+396	16.0	14.70	X	10	20	N	25.1	QSO	0.118
0950+664	16.7	17.00	X	15	16	Y	42.4	AGN	
1112+668	17.0	16.53	X	10	4	Y	47.9	QSO	0.544
1150+334	16.2	16.30	R	0.8	1.2	Y	76.0	QSO	1.40
1235+699	17.9	17.96	x	5	4	Y	47.4	QSO	0.522?
1255+447	16.5	16.48	X	10	13	Y	72.6	QSO	0.300
1315+447	17.0	17.33	x	5	15	Y	71.9	DZ:	
1324+448	17.0	18.09	X	8	9	Y	71.1	QSO	0.331?
1500+752	16.9	-	X	10	11	N	39.5	DA:	
1822+352	15.8	-	R	3.5	3.9	N	20.5	DA	
2308+425	13.5	-	X	12	8	N	-16.3		

X: in the ROSAT All Sky Survey Bright Source Catalogue; x: in the ROSAT WGACAT Catalogue; R: in the NRAO VLA Sky Survey; Y: in the PG area; N: not in the PG area; O: APS O magnitudes; (1): error of the ROSAT or VLA position (in arcsec); (2): distance between the FBS and ROSAT or VLA positions (in arcsec).

limits, while the optical position of FBS 1715+424 is about 42" away from the X-ray position; this is therefore a chance coincidence. Within 1 arcmin, we found 50 coincidences: 21 QSOs, 22 stars and seven unidentified objects listed in Table 2; recently, one of these objects (FBS 0950+664) has been identified on objective prism plates as an AGN [46].

3.2. *The ROSAT WGACAT catalogue of point sources.* The WGACAT catalogue has been generated using the ROSAT PSPC pointed data publicly available as of September 1994. It contains more than 45600 individual sources in a total of 2624 fields [47]. 13937 sources are located within the FBS area; we have cross-correlated this list with the FBS. There are 53 X-ray sources within two arcmin of a FBS object, while we expect 13 chance coincidences. 28 of them are also listed in the RASS catalogue. We have measured accurate optical positions for the 25 remaining objects (Table 1) and recomputed the separation with the companion X-ray sources. There are 13 FBS objects within 30" from an X-ray source (excluding the sources appearing in the RASS catalogue). Seven are QSOs, four are stars (including 3 CVs) and only two (listed in table 2) were of unknown nature before our spectroscopic observations.

3.3. *The IRAS point source catalogue.* We have cross-correlated the IRAS point source catalogue [48] with the FBS. There are 10537 IRAS sources in the area of interest. We expect ten chance coincidences within two arcmin from the 1103 FBS objects and 2.5 within one arcmin. We found 17 IRAS sources within two arcmin of the FBS objects. We have measured accurate optical positions for these objects (Table 1); two turned out to be more than two arcmin from the IRAS sources; one (FBS 1340+813), a white dwarf, is located near the bright K2 star SAO 2257 which is identified with the source IRAS 13407+8118 [17]. FBS 0432+763 is located near the M star SAO 5262 which is associated with the IRAS source. IRAS 04378+7532 is associated with the galaxy UGC 3130 rather than with FBS 0437+756. IRAS 16402+3611 is associated with the M star CLS 106 [49] rather than with FBS 1640+362. IRAS 17562+4412 coincides with an uncatalogued bright star and is therefore probably not associated with FBS 1756+441. These seven objects are certainly chance coincidences.

All the four FBS planetary nebulae are detected by IRAS, while none of the UV excess stars are. Five QSOs are also detected, i.e. only ~14% of all known QSOs in the field. The position of FBS 1821+643 coincides with that of the nucleus of the planetary nebula PK 094+27.1 [13]; it is not the QSO KUV 18217+6419 which is located 84" away. There is only one unclassified FBS object coinciding with an IR source, IRAS 11334+7523 which however is located 14" away from a 16^m galaxy which is a more likely identification.

The small fraction of all QSOs which are detected as IRAS sources make this survey of little use to check the completeness of the FBS.

3.4. *The Green Bank 6cm (GB6) radio survey.* The GB6 survey [50] covers the declination band $0° < \delta < 75°$. It contains 54579 sources stronger than 25 mJy. 16050 sources are within the FBS area. We expect 15 chance coincidences within two arcmin and four within one arcmin. We found 18 and 12 coincidences within two and one arcmin, respectively. Eight known QSOs are detected, all within 30" of the radio-positions. We have measured accurate optical positions (Table 1) for the ten remaining objects not known to be QSOs. We are left with three objects for which the distance between optical and radio positions is less than three times the quoted radio error. Two (FBS 0958+353 and 1534+389) are stars. A more accurate position of the third source associated with FBS 1619+749, measured with the NRAO VLA sky survey (see below), excludes this identification.

3.5. *The NRAO VLA sky survey.* The NRAO VLA Sky Survey (NVSS) covers the sky north of J2000 $\delta = -40°$. (82% of the celestial sphere) at 1.4 GHz [51]. It contains almost $2{\cdot}10^6$ discrete sources stronger than S = 2.5 mJy. The rms positional uncertainties vary from < 1" for sources stronger than 15 mJy to 7" at the survey limit. The source surface density is about 60 deg^{-2}.

We have searched the NVSS catalogue for sources within 2 arcmin from the FBS objects in the first four papers and within one arcmin in the last seven papers, excluding the known stars, in all 705 objects; 13 lie in as yet uncatalogued regions of the NVSS survey. We have found 54 coincidences; we have measured the accurate optical positions of these FBS objects (Table 1). Using these new optical positions, and excluding those objects for which the distance between radio and optical positions exceeds three times the radio-position error, we are left with ten coincidences, including eight known QSOs (three known extended radio quasars: B2 1512+37, 3C 249.1 and 3C 263.0 have been excluded by this procedure). The two new probable radio-identifications (listed in table 2) are FBS 1150+334 and 1822+352.

3.6. *The Westerbork Northern Sky Survey.* The Westerbork Northern Sky Survey (WENSS) is a low-frequency radio-survey that covers the whole sky north of $\delta = 30°$ at a wavelength of 92 cm to a limiting flux density of approximately 18 mJy [52]. The WENSS comprises two source catalogues: the main catalogue contains 211234 sources in the declination range $28° < \delta < 76°$ (83134 in the FBS area); the polar catalogue contains 18186 sources above 72° (12239 in the FBS area). The positional accuracy ranges from 1.5" for the brighter sources to 10" for the weakest. The source surface density is about 23 deg^{-2}. The total number of coincidences within one arcmin with FBS objects not known to be stars is equal to 19 (including eight known QSOs), while 15 are expected by chance. The distances between optical and radio positions for the eight QSOs are all smaller than 20"; for the unclassified objects, the smallest distance is 34", suggesting that no new QSO has been detected.

4. *Observations and data reduction.* Spectroscopic observations of nine of the twelve objects associated either with an X-ray or a radio source (Table 2) and of 22 other FBS objects were carried out on October 27 and 28, 1997 and on May 25 and 26, 1998 with the CARELEC spectrograph [53] attached to the Cassegrain focus of the Observatoire de Haute-Provence (OHP) 1.93m telescope. A 260 A/mm grating was used; the spectral range was 3810-7365A. The detector was a 512x512 pixels, 27x27 mm Tektronix CCD. The slit width was 2".1, corresponding to a projected slit width on the detector of 52 μm, or 1.9 pixel. The resolution, as measured on the night sky emission lines, was 14.3A FWHM. The spectra were flux calibrated using the standard stars EG 145 and Feige 66 [54] which were also used to correct the observations for the atmospheric absorption.

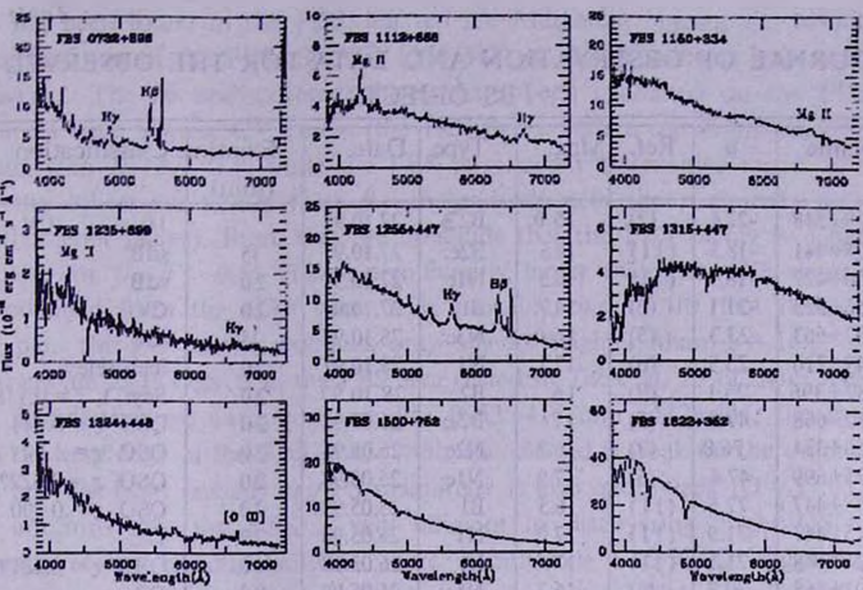

Fig.3. Spectra of the nine observed FBS objects identified either with an X-ray or radio source.

Six of the X-ray or radio sources turned out to be QSOs, while three are stars. The 22 other observed objects are all stars, except one which is a H II galaxy. The spectra of the first nine objects are presented in Fig.3.

The journal of observations is given in Table 3, together with relevant data.

5. *Discussion*. 5.1. *Completeness of the FBS.* The Catalogue of mean UBV data on stars [39] contains 102 stars in the FBS area, with $11.0 < V < 16.5$ (bright stars are saturated on the FBS plates and are therefore missed) and $U-B < -0.50$; 53 are included in the FBS catalogue suggesting that in this magnitude interval the completeness of the FBS is 52% (53/102). Only 9% (2/23) of the stars weaker than $V = 16.5$ appear in this catalogue. The survey is insensitive to objects with $U-B > -0.5$ (0/9); its completeness increases from ~20% at $U-B \sim -0.6$ to ~80% for $U-B < -1.0$. The QSO $U-B$ colour changes with z; but most of the changes, at least for $z < 2.2$, are due to the presence of an emission line in one of the two filters. The $U-B$ colour of the continuum is in the range $-0.9 < U-B < -0.7$. Slitless spectroscopic surveys are sensitive to the colour of the continuum, unaffected by the emission lines. There are 58 known stars with $14.0 < V < 16.5$ and $U-B < -0.70$ in the FBS area; 39 (67%) have been found by the FBS; we shall adopt this value as the completeness of this survey for QSOs brighter than $V = 16.5$.

The PG survey does not cover the region at galactic latitudes lower than 30°. The PG and FBS samples have about 2250 deg² in common. Out of the 1103 FBS objects, 618 are within the PG fields, 276 being in the PG sample. (FBS 0854+385 is PG 0854+385, but the original FBS R.A. is affected by a printing

Table 3

JOURNAL OF OBSERVATION AND DATA FOR THE OBSERVED FBS OBJECTS

Name	b	Ref.	Mag.	Type	Date	Exp.time (min)	Classification
0019+348	-27.4	(2)	15.0	B2 3	27.10.97		10 CV
0028+441	-18.3	(11)	14.5	B2e:	27.10.97	15	sdB
0140+427	-18.9	(11)	16.5	N1e	27.10.97	20	sdB
0306+333	-21.1	(2)	14.7	B1	27.10.97	20	CV:
0632+663	23.3	(5)	16.0	N3e:	28.10.97	15	sdB
0649+716	25.9	(6)	17.1	N1	28.10.97	20	featureless
0732+396	25.1	(9)	16.	B2	28.10.97	20	Seyf 1 $z = 0.118$
1112+668	47.9	(5)	17.	B2a:	26.05.98	20	QSO $z = 0.544$
1150+334	76.0	(2)	16.2	N2e:	26.05.98	20	QSO $z = 1.40$
1235+699	47.4	(6)	17.9	N1e	26.05.98	20	QSO $z = 0.522?$
1255+447	72.6	(11)	16.5	B1	25.05.98	20	QSO $z = 0.300$
1315+447	71.9	(11)	17.0	N1	25.05.98	20	DZ:
1324+448	71.1	(11)	17.0	B1	26.05.98	20	QSO $z = 0.331?$
1401+865	30.7	(8)	16.2	N1e:	25.05.98	20	DZ
1449+440	75.6	(12)	16.0	N1	26.05.98	20	F0
1452+762	39.0	(7)	16.0	N2e	25.05.98	20	sdB
1500+752	39.5	(7)	16.9	B2a	26.05.98	20	DA:
1523+363	56.3	(3)	16.1	N1	26.05.98	20	F0
1557+448	48.9	(12)	16.5	de:	25.05.98	20	H II $z = 0.0417$
1607+439	47.1	(12)	16.0	s1e:	26.05.98	20	F0:
1715+406	34.5	(6)	16.0	sd3e	25.05.98	20	sdF:
1716+394	34.2	(10)	17.0	N1e:	25.05.98	20	F0
1755+663	30.2	(5)	16.3	N2	26.05.98	20	F0
1810+374	23.4	(3)	15.7	B2	26.05.98	20	sdA
1819+348	20.9	(3)	14.8	B1e:	15.06.98	20	sdA
1822+414	22.4	(12)	14.5	B1	25.05.98	20	sdB-O
1822+352	20.5	(3)	15.8	B2	25.05.98	20	DA
1833+447	21.5	(12)	15.5	B1a	25.05.98	20	F0
2149+425	- 8.7	(12)	13.5	B1	27.10.97	5	sdB
2249+391	-17.9	(10)	16.5	N1e:	27.10.97	20	F5
2315+443	-15.2	(12)	17.	N2e:	27.10.97	20	F5

References are to the original lists of the FBS.

FBS 0732+396 was suspected of being non-stellar and having emission lines [9]. Our spectrum (Fig. 3) shows emisssion lines characteristic of a NLS1 galaxy at z = 0.118, with relatively narrow Balmer lines and strong Fe II lines.

FBS 1255+447 is HS 1255+4445 at z = 0.30 [25].

error; FBS 0935+395 is not a PG object; PG 0752+770, 0836+619, 1047+694, 1335+369, 1551+719, 1600+369, 1606+627, 1620+648 and 1722+353 are FBS objects, but their original PG positions are affected by errors reaching several arcminutes; the declination of FBS 1559+369 is affected by a printing error of one arcmin; it is G180-23 [55] and PG 1600+369; the declination of FBS 1619+648 is also affected by a printing error of one arcmin. The position of these objects has been measured and is given in Table 1). Forty-six PG objects have not been found in the FBS, but ten are Markarian objects, i.e. belong to the first part of the FBS. So 88% (276/312) of the PG objects have been discovered. The 36 undiscovered objects have been examined on the FBS plates; 24 have a weak UV excess (the PG survey finds a significant fraction of stars with $U-B \sim -0.4$, while the FBS is relatively unsensitive for $U-B >$ -0.7; the others are fainter than $B \sim 16.$ and are near the magnitude limit of rather poor plates). From this, we conclude that the FBS survey is ~90% complete for $U-B < -0.5$. This is significantly larger than the 67% success rate obtained from the *UBV* stars; it is probably due to the fact that, in principle, the PG survey contains only objects brighter than $B = 16.2$.

There are 25 PG QSOs in the FBS area (listed in Table 4), 23 of them have been found; the two exceptions are PG 0953+414 and 1112+431; the first is on the very edge of the FBS plate, while the second is weak on the original plate and has been missed; its APS magnitude is also quite weak (O = 17.03). This confirms that the FBS is very efficient in discovering bright QSOs. However, at low galactic latitudes, there is only one FBS QSO, suggesting a very low success rate which could be due in part to Galactic extinction and reddening and in part to crowding on the objective prism plates.

5.2. *The AGN content of the FBS.* Thirty-four FBS objects are listed as QSOs in the eight edition of the Véron-Cetty & Véron catalogue [26]. Two more (FBS 1102+347 and 1147+673) have been shown to be QSOs [56] and six have been identified in the present paper (Table 2). There are therefore 42 known QSOs in the FBS, 41 being at high galactic latitude ($|b| > 30°$).

At high galactic latitudes, all FBS objects associated with a ROSAT RASS-BSC source have been identified. Among them, there are 25 QSOs with known z, and one without, alltogether 26. As about 60% of all PG QSOs are RASS sources, and assuming that this is true for the FBS QSOs, we should have a total of about 43 QSOs in the FBS catalogue (including the one without known z). This suggests that the number of QSOs still to be found in the FBS catalogue is very small as 42 have already been found.

All 114 AGNs from the PG survey have been observed at 5 GHz with the VLA [57]; thirty five (30%) have been detected with a flux density larger than 3 mJy. The same fraction (12/40) of the known FBS QSOs have been detected in the NVSS survey, suggesting that the number of QSOs in the as yet spectroscopically unobserved FBS objects is small and probably cannot exceed about 10, as the fraction of radio-detected QSOs would then drop below 25% and be significantly lower than the corresponding fraction for the PG survey.

5.3. *Completeness of the PG survey.* Goldschmidt et al. [3] have found a systematic difference of $0^m.28$ between the PG magnitudes and their own measurements for 25 PG stars, the PG magnitudes being too bright; they suggested that this difference was due to a zero-point error in the PG magnitude

Table 4

PG AND FBS QSOs IN THE FBS AREA

Position	z	B	O	M_B	Catalogue, survey, area			b	Name
0732+396	0.118	16.:	14.70	-24.6	X	N	F	25.1	
0804+761	0.100	15.15	14.18	-24.4	X	Y	PF	31.0	
0838+770	0.131	16.30	17.55	-22.0	X	Y	PF	32.7	
0844+349	0.064	14.00	16.89	-20.7	X	Y	PF	38.0	
0931+437	0.456	16.41	16.47	-25.8	X	Y	PF	47.4	US 737
0935+416	1.966	16.30	16.07	-29.6	-	Y	PF	48.3	
0936+396	0.458	16.30	16.69	-25.6	-	Y	PF	48.6	
0947+396	0.206	16.40	16.39	-24.1	X	Y	PF	50.7	
0953+415	0.239	15.05	15.59	-25.3	X	Y	P	51.7	
0959+685	0.773	16.28	16.01	-27.1	x	Y	F	42.0	
1002+437	0.178	15.:	16.39	-23.8	X	Y	F	52.9	
1007+417	0.613	15.:	16.04	-26.9	X	Y	F	54.2	4C 41.21
1048+342	0.167	15.81	15.94	-24.2	X	Y	PF	63.4	
1049+617	0.421	16.66	16.62	-25.3	X	Y	F	50.4	4C 61.20
1100+772	0.313	15.86	15.93	-25.6	X	Y	PF	38.6	3C 249.1
1102+347	0.51	16.2	-	-26.2	-	N	F	66.2	CSO 314
1112+668	0.544	17.0	16.53	-26.1	X	Y	F	47.9	
1112+431	0.302	16.20	17.03	-24.4	-	Y	P	64.9	
1114+445	0.144	16.05	15.11	-24.6	x	Y	PF	64.5	
1115+407	0.154	16.02	14.57	-25.3	X	Y	PF	66.7	
1121+422	0.234	16.02	15.84	-24.6	X	Y	PF	66.9	
1137+661	0.650	16.50	16.25	-26.6	X	Y	F	49.7	3C 263.0
1140+680	0.796	17.0	16.82	-26.8	X	Y	F	48.1	
1147+673	1.02	16.7	16.69	-27.2	-	Y	F	49.1	
1150+334	1.40	16.2	16.30	-28.8	R	Y	F	76.0	CSO 373
1229+710	0.208	15.4	15.66	-24.9	X	Y	F	46.3	
1235+699	0.522	17.9	17.96	-24.5	x	Y	F	47.4	
1242+342	0.717	17.3	17.52	-25.8	-	Y	F	83.1	CSO 919
1248+401	1.032	16.06	16.33	-28.0	X	Y	PF	77.3	
1255+447	0.300	16.5	16.48	-24.9	X	Y	F	72.6	
1309+355	0.184	15.45	15.64	-24.7	X	Y	PF	80.7	
1322+659	0.168	15.86	15.71	-24.2	X	Y	PF	51.1	
1324+448	0.331	17.:	18.09	-23.5	X	Y	F	71.1	
1329+412	1.937	16.30	16.78	-29.1	-	Y	PF	73.8	
1338+416	1.204	16.08	16.50	-28.1	-	Y	PF	72.5	
1351+640	0.088	15.42	-	-22.3	x	Y	PF	52.0	
1402+436	0.320	15.:	-	-25.4	-	Y	F	68.0	CSO 409
1411+442	0.089	14.99	-	-22.6	x	Y	PF	66.4	
1444+407	0.267	15.95	-	-24.9	X	Y	PF	62.7	
1512+370	0.370	15.97	-	-25.8	X	Y	PF	58.3	B2 1512+37
1526+659	0.345	17.0	16.90	-24.8	x	Y	F	44.4	
1630+377	1.478	15.96	16.62	-28.5	x	Y	PF	42.9	
1634+706	1.337	14.90	15.27	-29.7	x	Y	PF	36.6	
1641+399	0.594	16.25	15.87	-26.7	X	Y	F	40.9	3C 345.0

Y: in the PG area; N: not in the PG area; P: in the PG catalogue; F: in the FBS catalogue; R: in the NRAO VLA Sky Survey; X: in the ROSAT All Sky Survey Bright Source Catalogue; x: in the ROSAT WGACAT catalogue; O: APS O magnitudes.

scale. The mean differences between the PG and photoelectric magnitudes for 105 stars is equal to $0^m.00$; this does not confirm the existence of an systematic offset in the PG scale. The quoted error for the PG photographic B magnitude is $\sigma = 0^m.29$ [1]. The comparison with photoelectric magnitudes gives $\sigma = 0^m.37$ (Fig.4b).

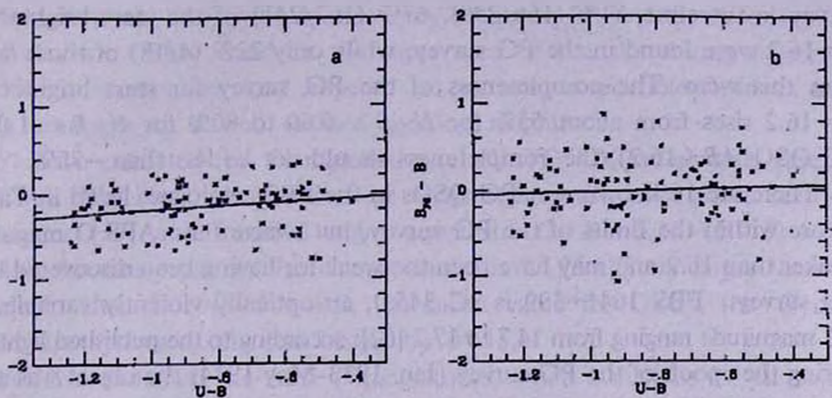

Fig. 4. a) Plot of the differences between the APS *O* magnitudes and the photoelectric *B* magnitudes for 105 PG objects. b) Plot of the differences between the PG photographic and the photoelectric *B* magnitudes for the same 105 objects. In the two figures, the straight lines represent the best fits through the data.

It has been suggested [7] that, on average, the PG magnitudes for QSOs are too bright; as we do not observe such an effect for the stars, we suggest that this is due to the QSO variability; QSOs are discovered preferentially when they are bright; when measured at an epoch different from the survey epoch they are found to be systematically weaker by a few tens of a magnitude [58].

The QSO counts are systematically affected by the photometric errors in *B* as these errors scatter many more objects toward brighter magnitudes than it does toward fainter magnitudes. Assuming that the error distribution is Gaussian, with dispersion sigma, the correction to be applied to the observed counts is a factor $10^{(b+1)\sigma^{*2}/2}$ where b is the slope of the integrated number-magnitude relation: $\log N(<B) = a + b \cdot \mathrm{B}$ [59,2]. Assuming $b = 0.75$, if $\sigma = 0^m.27$, the true QSO surface densities are smaller by 1.16 than the observed ones; if $\sigma = 0^m.37$, the correction is 1.32.

In principle the PG survey selected all objects with $U - B < -0.46$ (and brighter than $B \sim 16.2$); however, the $U - B$ colour was measured with a relatively large error ($0^m.24$ r.m.s.) which induced an incompleteness estimated at around 12% [2]. Moreover, in the interval $0.6 < z < 0.8$, the strong Mg II λ2800 emission lines are in the *B* filter which results in a much redder $U - B$ colour than for neighbouring redshifts; as a result in this interval the PG survey picked up too few quasars and was estimated to be only 72% complete [2].

The catalogue of mean *UBV* data on stars [39] contains 283 stars in the magnitude range $12.0 < B < 16.5$ and with $U-B < -0.40$ in the full 10714 deg^2 area of the PG survey; 190 are included in the PG catalogue (there are 59 stars fainter than $B = 16.5$ in the PG area, but only two are included in the PG catalogue). Twenty four stars photoelectrically observed because they were in the PG catalogue [60,61] have been ignored. The overall completeness of the PG survey is therefore 64% (166/259). 67% (162/241) of the stars brighter than $B = 16.2$ were found in the PG survey, while only 22% (4/18) of those weaker than this were. The completeness of the PG survey for stars brighter than $B = 16.2$ rises from about 55% for $U-B > -0.60$ to 80% for $U-B < -1.0$. For PG QSOs ($B < 16.2$), the completeness should not be less than ~70%.

There are 19 known non-PG QSOs in the FBS catalogue, listed in Table 4; 17 are within the limits of the PG survey, but twelve have APS O magnitudes weaker than 16.2 and may have been too weak for having been discovered by the PG survey. FBS 1641+399 is 3C 345.0, an optically violently variable, with a B magnitude ranging from 14.7 to 17.7 [62]; according to the published lightcurve, during the epoch of the PG survey (Jan. 1973-May 1974) the object was always fainter than $B = 16.4$ and was most probably weaker than the plate limit. The published magnitudes for FBS 1402+436 are inaccurate and in poor agreement ($B = 15 \pm 0.75$ [20], $B = 16$ [63], $V = 16.5$ [64]), suggesting that this object could have been weaker than the PG limiting magnitude. We are left with only three bright FBS QSOs missing from the PG catalogue implying an incompleteness of 15% (assuming that the FBS is 70% complete). Two of them are in the z range (0.6 - 0.8) in which the $U-B$ excess is reduced because of the presence of the Mg II line in the B filter which could explain their absence from the PG survey.

Wampler & Ponz [7] suggested that the incompleteness of the PG survey could be substantial. Goldschmidt et al. [3] found five new QSOs with $B < 16.17$ in a 330 deg^2 area included in the PG area where Green et al. [1] found only one; they got a surface density of 0.018 deg^{-2}, about three times larger than PG. We have obtained a spectrum of one of them (Q 1404-0455) which shows it to be a starburst galaxy at $z = 0.029$. For two others, the O magnitudes extracted from the APS database [65] are greater than 16.5; it is not clear if this is due to variability or to a difference in the magnitude scales. In these conditions, it seems hazardous to conclude to a gross incompleteness of the PG survey on the basis of these data. Köhler et al. [4] surveyed a 611 deg^2 area and concluded to an incompleteness of the BQS by a factor 2 to 3; they found eight QSOs brighter than $B = 16.16$, or 0.013 deg^{-2}. La Franca & Cristiani [5] have surveyed an area of 555 deg^2 in the magnitude range $15 < B < 18.75$; they found that, for magnitudes brighter than $B = 16.4$, the QSO surface density (0.013 deg^{-2}, derived from seven objects) is a factor 2.2 higher than the PG value. Savage et al. [6] found 16 QSOs brighter than $B = 16.16$ in a 1500 deg^2 area or 0.011 deg^{-2}. These samples are quite small; the zero-point errors of their magnitude scales have not been determined. These results should be considered as tentative.

6. *Building a «complete» QSO survey based on APS O magnitudes.* Because of their variability, it is an impossible task to compare two QSO surveys of the same region of the sky made at different epochs. However we now have, for a large fraction of the sky, the possibility to extract from the APS database, for any object, the O magnitude as measured on the Palomar Sky Survey plates [65] with an accuracy of about $0^m.2$ [66]. By doing this for all known QSOs found in the same area of the sky during a number of different surveys, we may hope to get as near as possible from an ideal survey complete to a well defined limiting magnitude.

We have extracted the O magnitudes of 105 PG UV-excess stars (excluding CVs). We have compared these magnitudes with the photoelectric B magnitudes [39] and found a color equation: $O - B = 0.23 \cdot (U - B) + 0.02$ (Fig.4a); the rms error on the O magnitudes is $0^m.26$ slightly larger than the published value. For $U - B = -0.8$, the mean value for QSOs, the O magnitudes are systematically too bright by $0^m.16$.

We have extracted the APS O magnitudes, when available, for all objects in the QSO catalogue [26] brighter than $B = 17$, with $M_B < -24.0$ and $z < 2.15$, located in the 2400 deg^2 of the FBS at $|b| > 30°$. Whenever this O magnitude exists, we give it the preference. Table 4 contains 15 such QSOs with $O < 16.2$ (and 11 with $O < 16.0$, corresponding to $B = 16.2$) and three with $B < 16.2$. We have found ten additional QSOs with $O < 16.2$ (seven with $O < 16.0$) and four with $B < 16.2$ (listed in table 5).

Table 5

BRIGHT (O < 16.2) QSOs AT $|b| > 30°$ NOT IN THE FBS

Name	Position	z	B	O	M_B	Catalogue		b
HS 0806+6212	0806+62	0.173	16.5	16.12	-24.0	-	Y	33.0
KUV 08126+4154	0812+41	1.28	16.4	15.91	-28.9	-	Y	32.9
US 1329	0833+44	0.249	15.6	15.24	-25.7	X	Y	37.0
KUV 09468+3916	0946+39	0.360	16.1	15.99	-25.8	X	Y	50.6
RX J10265+6746	1022+68	1.178	15.0	-	-29.6	-	Y	43.9
KUV 11274+4133	1127+41	0.72	16.93	16.12	-27.0	-	Y	68.1
HS 1312+7837	1312+78	2.00	16.4	15.84	-30.1	-	N	38.7
CSO 1022	1351+36	0.284	16.	-	-25.3	-	Y	73.9
RX J14249+4214	1422+42	0.316	15.7	-	-25.8	X	Y	65.7
B3 1621+392	1621+39	1.97	16.7	15.86	-30.0	X	Y	44.7
RXS J16261+3359	1624+34	0.204	16.5	15.82	-24.7	X	Y	43.8
RXS J17060+6857	1706+69	0.449	16.3	16.04	-26.2	X	N	34.6
HS 1710+6753	1710+67	0.41	16.4	15.94	-26.1	-	N	34.5
B2 1721+34	1721+34	0.206	15.46	-	-25.0	X	Y	32.2

Y: in the PG area; N: not in the PG area; X: in the ROSAT All Sky Survey Bright Source Catalogue; O: APS O magnitudes.

Thus our «complete» sample contains between 18 and 25 QSOs brighter than $B = 16.2$ or 0.0075 to 0.010 deg^{-2}; this is 1.2 to 1.6 times larger than the PG surface density. If we correct these surface densities for the Eddington effect (1.16 for our survey and 1.32 for the PG survey), our surface densities are 1.4 to 1.8 times larger than the PG values.

It should be possible, when the APS database will be completed, to check the O magnitudes of the seven objects for which they are not yet available.

Acknowledgements. A.M.Mickaelian is grateful to the CNRS for making possible his visit to Observatoire de Haute-Provence for carrying out this work. A.C.Gonçalves acknowledges support from the *Fundação para a Ciência e a Tecnologia*, Portugal (PRAXIS XXI/BD/5117/95 Ph.D. grant).

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О ПРИРОДЕ ГОЛУБЫХ ЗВЕЗДНЫХ ОБЪЕКТОВ FBS И ПОЛНОТЕ ОБЗОРА ЯРКИХ КВАЗАРОВ

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Вторая часть Первого Бюраканского Обзора (FBS) направлена на обнаружение всех ярких ($B < 16.5$) звездообразных объектов с УФ-избытком на большой площади неба. Путем сравнения с другими основными обзорами, такими как Обзор всего неба ROSAT, Каталог точечных источников ROSAT WGACAT, Обзор IRAS, Обзор Грин Бэнк на 6см, Обзор NRAO VLA на 1.4 ГГц и Вестерборкский Обзор северного неба на 92см, а также с каталогом средних *UBV* данных звезд, мы оцениваем количество активных галактических ядер в FBS и его полноту. Мы проводили спектроскопические наблюдения 9 наиболее интересных кандидатов в квазары из FBS. Обнаружено 6 новых квазаров, которые доводят полное число известных QSO в этом обзоре до 42. Путем сравнения с Обзором ярких квазаров BQS, мы нашли, что полнота этого последнего обзора порядка 70% по сравнению с 30-50%, предложенными рядом авторов.

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