An AGN sample with high X-ray-to-optical flux ratio from RASS

I. The optical identification

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Abstract. We present the first results of a program to identify the unknown bright active galactic nuclei (AGN) in the ROSAT All Sky Survey Bright Source Catalog (RASS-BSC). We have used $\log C + 0.4 R$ as an alternative expression for $\log(f_X/f_{\text{opt}})$, where C is X-ray count rate and R stands for R magnitude. Then a high X-ray-to-optical flux ratio criterion has been used to select an AGN sample with 165 unidentified X-ray sources for optical spectroscopy. Those 165 X-ray sources have been identified in the following classes: 115 emission line AGN (QSOs and Seyferts), 2 BL Lac objects and 4 BL Lac candidates, 22 clusters of galaxies, 12 Galactic stars and 10 objects remain unidentified. This represent a success rate of about 73% for detecting AGN using our selection criteria. Plausibility is based upon the optical classification and X-ray characteristics of the sources.

Key words: surveys — X-rays: general — X-rays: galaxies — galaxies: active

1. Introduction

During the ROSAT All-Sky Survey (RASS; Voges 1992, 1997) about 80000 X-ray sources with a detection likelihood ≥ 10 were detected, from which 18 811 sources having a PSPC count rate larger than 0.05 cts s^{-1} and detection likelihood ≥ 15 were compiled in the RASS-BSC (Voges et al. 1996a). More than 65% RASS sources remain unidentified (Voges et al. 1996b). The optical identification of this large numbers of X-ray sources is a challenge. In order to obtain the statistical classification of the RASS sources, several optical identification programs have been carried out (Appenzeller et al. 1998; Fischer et al. 1998; Hasinger et al. 1998; Schmidt et al. 1998; Thomas et al. 1998).

The identification of X-ray sources has proved to be an effective means of creating samples of Active galactic nuclei (AGN). The present program aims at creating a new bright sample of AGN which have the highest X-ray-to-optical flux ratios for statistical investigation. The results of the EMSS (Stocke et al. 1991) have shown that different classes of X-ray sources represent different narrow ranges in the X-ray-to-optical flux ratios. These bounds mean the X-ray sources with Galactic and extragalactic counterparts can be separated at high confidence level *prior to any optical spectroscopy* (Maccacaro et al. 1988).

Sections 2 and 3 review the creation and follow-up optical spectroscopic observations of the sample. Section 4 gives details of the optical identification procedure. The final section presents the results. A Hubble constant of $H_0 = 50 \text{ km s}^{-1} \text{ Mpc}^{-1}$ and cosmological deceleration parameter of $q_0 = 0$ are used throughout.

2. Sample selection

The alternative expression for X-ray-to-optical flux ratio $\log(f_X/f_{\text{opt}})$ comes from the statistical analysis of known RASS-BSC X-ray sources. The sources which have an entry in SIMBAD, NED, the catalogs of AGN (Véron-Cetty & Véron 1996), or other available databases are considered as known.

The X-ray sources with the highest X-ray-to-optical flux ratio are: BL Lac objects, emission line AGN, clusters of galaxies etc. However, X-ray flux is difficult to evaluate before optical identification. Although for a given spectral energy distribution the conversion of X-ray count rate to flux depends on the column density N_H , the X-ray flux (f_X) is nevertheless roughly proportional to the count rate (C), so X-ray flux in the X-ray-to-optical flux ratio criterion can be replaced by X-ray count rate, i.e., $\log(f_X/f_{\text{opt}}) \propto \log C + 0.4 R + \text{constant}$, where we use the R magnitude flux to represent the optical flux. For fixed $\log(f_X/f_{\text{opt}})$, $\log C + 0.4 R =$

Fig. 1. Count rates as a function of R magnitudes for known sources

constant. According to our statistical analysis of known RASS-BSC X-ray sources, we found that there is an apparent gap between Galactic stars and extragalactic objects. As can be seen in Fig. 1, 92% AGN concentrate in the region: $\log C \geq -0.4 R + 4.9$. O–M spectral type stars in this region are only 3% of its total amount included in the statistics. Thus, choosing $\log C \geq -0.4 R + 4.9$ is expected to be efficient for the preselecting of AGN and can avoid too many O–M stars being included in the sample.

Considering the observatory site, instruments and possible observation times, we selected our sample from RASS-BSC according to the following criteria:

1. Unknown sources which do not have an entry in SIMBAD, NED, or other available databases.
2. Declination $\delta \geq 3^\circ$.
3. Galactic latitude $|b| \geq 20^\circ$.
4. Optical counterparts within a circle with radius $r = r_1 + 5''$, where r_1 is the RASS position error given by Voges et al. (1996).
5. Optical counterparts with R magnitudes between 13.5 and 16.5.
6. $\log C \geq -0.4 R + 4.9$.

For the search of optical counterparts we adopt the error circle with radius r , 87% of known AGN are found within r from X-ray position. For each object inside the error circle, we obtain its R magnitude from USNO-A1.0¹ and check whether it satisfies the flux ratio criterion. Only X-ray sources which have at least one object inside the

error circle which meets the criterion are included in the sample. A sample with 165 unidentified X-ray sources with Right Ascension between 19^h and 8^h was selected for optical spectroscopy from RASS-BSC. Table 2 summarizes the general information for the observed objects as following:

Column (1): ROSAT (1RXS J) source designation.

Columns (2) & (3): Optical right ascension α and declination δ of the proposed optical counterpart² (epoch 2000.0) derived from the Digitized Sky Survey (DSS)³ images which should be better than $2''$ (Irwin et al. 1994).

Column (4): ROSAT X-ray position error as given in RASS-BSC.

Column (5): Angular Separation between the X-ray source and the proposed optical counterpart in arcsecond.

Column (6): ROSAT total count rate (in counts s^{-1}) as given in RASS-BSC.

Column (7): Hardness ratio $HR1 = (B - A)/(B + A)$, where A means the count rate in the energy range 0.1 – 0.4 keV and B in the energy range 0.5 – 2.0 keV.

Column (8): Hardness ratio $HR2 = (D - C)/(D + C)$, where C means the count rate in the energy range 0.5 – 0.9 keV and D in the energy range 0.9 – 2.0 keV.

Column (9): Extent in arcsecond as given in RASS-BSC.

Columns (10) & (11): The R and B magnitudes obtained from USNO-A1.0 with an accuracy between 0.25 and 0.40

² In cases which final identification is not the proposed one, we list information for the real counterpart too.

³ The Digitized Sky Survey, 1994, CD-ROM Version, Space Telescope Science Institute.

¹ USNO-A1.0, 1996, CD-ROM version, U.S. Naval Observatory.

magnitudes depending on the declination (Monet et al. 1996).

3. Optical spectroscopic observations and data reduction

All sources were investigated during several observing runs performed at Xinglong station, Beijing Astronomical Observatory (BAO) from November 1996 through September 1998. The low resolution spectra were taken with the BAO 2.16 m telescope and the OMR spectrograph, using a Tektronix 1024×1024 CCD as detector. Two gratings of 300 g mm^{-1} and 150 g mm^{-1} were employed in order to get large wavelength coverage. All observations were made through a $2.3''$ slit which produced a resolution of 10 to 11 Å and 20 to 22 Å as measured from the comparison spectra. Exposure time was generally between 1200 s and 3600 s depending on the brightness of the object. For a few objects, observations were performed twice in order to get a higher S/N ratio spectrum. All observations were obtained at airmass less than 1.5.

The raw two-dimensional data were reduced following standard procedures using the IRAF program package. The CCD reductions included bias subtraction, flatfield correction and cosmic-ray removal. Wavelength calibration was carried out using helium-neon-argon lamps taken at the beginning and end of the night. The flux calibration was derived with 2 to 3 observations of KPNO standard stars (Massey & Strobel 1988) per night. The atmospheric extinction was corrected by using the mean extinction coefficients for Xinglong Station, which were measured by Beijing- Arizona-Taiwan-Connecticut (BATC) multi-color survey (Yan 1995). The telluric O_2 absorption bands at 6870 Å and 7620 Å were not removed. The final calibrated spectra are shown in Fig. 2. Some of the spectra were taken under nonphotometric conditions so that the flux density scale given in the figures should be used only as a rough guide to the brightness of the sources.

4. Criteria for classification

The optical spectra are classified in a manner similar to related optical identification programs of X-ray sources (Stocke et al. 1991; Appenzeller et al. 1998). In the present investigation the plausibility is based on the optical classification and X-ray characteristics like hardness ratios and extension parameter. In many cases an unambiguous identification of an object as optical counterpart is possible using only the spectroscopy and imaging information from the POSS. However, we found a few cases where the optical classification alone does not allow a decision whether the proposed optical counterpart to the X-ray source is a plausible one. In these special cases additional information on the nature of the X-ray sources derived from RASS-BSC was used to check the plausibility. Bade et al. (1994)

discussed the X-ray properties of white dwarfs (very soft X-ray colors) and nearby clusters of galaxies (hard and extended X-ray emission). Pietsch et al. (1998) also used a conservative extent criterion (extent likelihood > 10 and extent $> 30''$) as an indicator that the X-ray emission does not originate from a nuclear source.

The redshifts of the spectral features are used to discriminate between X-ray sources with Galactic and extragalactic counterparts. Since our spectral resolution is insufficient to detect emission components in the Ca II resonance lines, we use Balmer emission components as tracers for coronal activity. Among 12 Galactic stars, 3 are M stars with molecular absorption bands, 3 are white dwarfs with very blue continuum and broad Balmer lines in absorption, and 6 are cataclysmic variable stars with Balmer emission lines present in the spectra.

Extragalactic counterparts in the sample are classified with emission line AGN, clusters of galaxies, BL Lac objects and their candidates. Generally, normal galaxies are not expected to be strong X-ray emitters and plausible candidates for the sample's counterparts. Objects with broad ($FWHM > 1000 \text{ km s}^{-1}$) and strong ($W_\lambda \gg 5 \text{ Å}$) permitted emission lines are classified as emission line AGN. The spectroscopic and imaging criteria required to identify an X-ray source as a cluster of galaxies involve the spectrum of a normal galaxy and visual evidence for the cluster on the POSS.

Indications pointing to a BL Lac nature of a specific source are: absence of emission lines with $W_\lambda \geq 5 \text{ Å}$, contrast of the Ca II break from the host galaxy small than 25%. Four objects with seemingly normal galaxy spectra are classified as BL Lac candidates due to their centimeter radio fluxes, high X-ray luminosities and consistent ($\alpha_{\text{ox}}, \alpha_{\text{ro}}$) values. The use of the $\alpha_{\text{ox}} - \alpha_{\text{ro}}$ diagram for classification was discussed by Stocke et al. (1991) and Nass et al. (1996). It was noticed that X-ray selected BL Lac objects contain a greater percentage of starlight due to the underlying galaxy than radio-selected BL Lac objects. Browne & Marchã (1993) also pointed out the possibility of misclassified X-ray sources as elliptical galaxies or clusters of galaxies. We tried without success to find other plausible counterparts since other objects visible on the POSS within the error circle are too faint to be observed with the 2.16 m telescope. However, we can not exclude that the counterparts are among these faint objects. Further observations, imaging and spectroscopy, are needed in these fields. Table 1 gives the X-ray parameters for these four BL Lac candidates. The X-ray flux is the unabsorbed flux in units of $10^{-12} \text{ ergs cm}^{-2} \text{ s}^{-1}$ and has been computed assuming a power law spectrum and Galactic absorption. The radio fluxes at 1.4 GHz are taken from the NRAO VLA Sky Survey (NVSS, Condon et al. 1998). The two-point spectral indices $\alpha_{\text{ox}} = -\log(S_{2\text{keV}}/S_{2500 \text{ Å}})/2.605$ and $\alpha_{\text{ro}} = \log(S_{5 \text{ GHz}}/S_{2500 \text{ Å}})/5.38$ (Stocke et al. 1985; Tananbaum et al. 1979) have been K-corrected for the

Fig. 2. Optical spectra of the counterparts to the X-ray sources. f_{λ} in units of $10^{-15} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ \AA}^{-1}$ is plotted against wavelength in $\text{\AA}$

Fig. 2. continued

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Fig. 2. continued

Fig. 2. continued

Table 1. X-ray parameters for four BL Lac candidates

ROSAT name 1RXS J	z	CR	$\Gamma_{\text{Gal}}^{\dagger}$	f_{X} e-12	L_{X} erg s $^{-1}$	f_{r} mJy	α_{ox}	α_{ro}
073720.4+351752	0.213	0.090	1.46	1.69	$3.64 \cdot 10^{45}$	27.2	1.19	0.43
082814.5+415359	0.223	0.089	1.60	1.69	$4.13 \cdot 10^{44}$	91.0	1.19	0.52
084829.3+811145	0.175	0.118	3.38	3.42	$6.67 \cdot 10^{44}$	12.9	1.11	0.36
221944.6+212054	0.20	0.080	2.65	2.83	$6.64 \cdot 10^{44}$	177.6	1.43	0.43

redshift of the object by assuming spectral slopes within each band of $\alpha_{\text{r}} = -0.7$; $\alpha_{\text{x}} = -1$ and $\alpha_{\text{o}} = -1.4$ (Ghisellini et al. 1986).

X-ray photon index for a power law fit with Galactic absorption.

5. Results

At present over 93% of the 165 X-ray sources have been successfully identified in the following classes: 115 emission line AGN (QSOs and Seyferts), 2 BL Lac objects and

4 BL Lac candidates, 22 clusters of galaxies, 12 Galactic stars. The other 10 X-ray sources remain unidentified because the proposed stellar counterparts are too faint to be the likely X-ray emitters. This represents a success rate of about 73% for detecting AGN using our selection criteria.

The final results of the identification are listed in Table 2 containing the following information in Cols. 12 to 14:

Column (12): Identification classification of the counterpart based on the criteria described in Sect. 4.

Table 2. X-ray identification information

ROSAT name	RA	Dec	P.E	D	CR	HR1	HR2	ext	R	B	ID	z	M _B
1RXS J	(2000)	(2000)	($''$)	($''$)	(cts s ⁻¹)			($''$)					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
000011.9+052318	00 00 11.76	05 23 17.3	7	2.2	0.264	0.24	0.00	0	15.5	16.4	Sey	0.040	-20.5
000055.5+172346	00 00 55.98	17 23 39.0	12	9.8	0.065	0.10	-0.13	14	16.5	17.2	QSO	0.215	-23.4
000550.0+102249	00 05 49.54	10 22 37.2	9	13.6	0.073	0.85	-0.08	0	15.9	16.7	Sey	0.095	-22.1
000620.3+105207	00 06 20.33	10 51 51.0	27	16.0	0.135	0.91	0.72	100	14.9	18.0	CL	0.167	
000915.0+243758	00 09 15.21	24 37 39.3	20	18.9	0.118	0.45	-0.30	21	16.4	17.6	Sey	0.118	-21.7
000953.0+371906	00 09 52.42	37 19 10.1	13	8.0	0.082	0.70	-0.20	0	15.5	16.6	QSO	0.154	-23.3
001121.2+373919	00 11 21.02	37 39 23.0	11	4.5	0.126	0.90	0.21	21	15.2	16.5	Sey	0.104	-22.5
001452.7+270549	00 14 53.04	27 05 41.5	11	8.8	0.171	0.18	0.15	7	15.6	16.4	Sey	0.086	-22.2
002007.2+324423	00 20 07.31	32 44 09.9	12	13.2	0.083	0.54	0.09	0	15.6	17.0	Sey	0.082	-21.5
002136.8+280305	00 21 36.32	28 03 10.9	23	8.7	0.160	1.00	0.17	78	13.4	16.3	CL	0.094	
	00 21 35.42	28 03 18.0		22.4					14.9	18.3			
	00 21 36.87	28 03 01.9		3.2					11.7	15.1			
002433.0+331237	00 24 32.89	33 12 24.6	27	12.5	0.097	0.74	0.11	72	15.0	19.0	CL	0.225	
002445.3+082047	00 24 45.75	08 20 56.6	20	11.7	0.060	0.04	-0.76	0	15.8	17.2	Sey	0.067	-20.8
002811.6+310342	00 28 10.76	31 03 47.8	9	12.3	0.168	0.64	0.05	14	15.3	15.8	QSO	0.500	-26.7
002902.7+195717	00 29 02.95	19 57 09.9	10	7.9	0.082	0.68	0.34	0	16.5	17.5	QSO	0.264	-23.6
003121.2+301558	00 31 22.02	30 16 02.1	14	11.4	0.050	0.34	-0.01	0	16.3	18.2	Sey	0.200	-22.7
003221.1+242359	00 32 21.04	24 23 59.3	13	0.9	0.090	0.42	-0.26	0	15.4	17.3	Sey	0.066	-20.7
003952.8+313228	00 39 51.92	31 32 31.7	10	11.8	0.135	-1.00	0.00	0	14.6	14.7	WD		
004459.4+192143	00 44 59.13	19 21 40.8	9	4.4	0.166	-0.20	-0.22	0	16.1	16.4	QSO	0.179	-23.8
005034.2+044152	00 50 33.77	04 41 48.8	11	7.2	0.052	-0.08	0.29	0	15.7	17.2	Sey	0.097	-21.7
005050.6+353645	00 50 50.79	35 36 42.3	8	3.6	0.285	0.13	-0.14	10	14.0	14.6	QSO	0.058	-23.1
005607.6+254802	00 56 07.70	25 48 04.9	10	3.2	0.125	0.38	0.14	9	15.6	16.7	QSO	0.153	-23.2
011216.3+330243	01 12 17.13	33 02 41.3	15	10.6	0.056	0.79	0.29	0	16.4	18.8			
011655.1+254937	01 16 54.07	25 49 27.8	12	16.7	0.079	0.95	0.51	13	15.3	16.7	Sey	0.099	-22.2
011745.5+363718	01 17 45.64	36 37 14.1	8	4.3	0.213	0.78	0.08	8	15.3	16.3	Sey	0.107	-22.8
011747.9+361042	01 17 49.45	36 10 26.2	24	24.5	0.056	0.10	0.53	0	16.5	18.7			
011848.2+383626	01 18 49.48	38 36 19.6	15	16.3	0.059	0.00	-0.46	19	16.4	16.8	QSO	0.216	-23.8
012028.0+384918	01 20 26.39	38 49 15.5	28	19.0	0.089	1.00	0.29	62	16.4	17.4			
012556.6+351039	01 25 55.96	35 10 36.9	13	8.1	0.059	0.68	0.38	0	15.6	17.3	QSO	0.312	-24.2
012923.0+223100	01 29 22.48	22 31 10.6	12	12.8	0.058	0.65	0.16	0	16.4	17.0	QSO	0.231	-23.8
013632.9+390556	01 36 32.60	39 05 59.1	7	4.7	0.750	0.76	0.22	8	14.9	15.9	BL		
013738.5+852414	01 37 37.21	85 24 10.7	8	3.7	0.061	0.77	0.41	0	16.3	17.0	QSO	0.499	-25.5
013853.1+252325	01 38 52.82	25 23 25.2	9	3.8	0.532	-0.93	1.00	28	15.9	15.5	WD		
014023.0+240255	01 40 22.91	24 02 51.3	13	3.9	0.140	0.79	-0.05	27	15.9	17.0	Sey	0.072	-21.2
014025.2+382400	01 40 24.35	38 24 09.3	9	13.6	0.212	0.39	0.00	7	16.1	16.9	Sey	0.067	-21.1
014732.3+345358	01 47 32.37	34 53 54.4	8	3.7	0.182	-0.30	0.23	0	14.2	16.9	M		
015505.4+335452	01 55 06.26	33 55 12.0	20	22.7	0.222	1.00	0.33	77	16.2	18.8	CL	0.092	

Table 2. continued

ROSAT name	RA	Dec	P.E	D	CR	HR1	HR2	ext	R	B	ID	z	M _B
1RXS J	(2000)	(2000)	($''$)	($''$)	(cts s ⁻¹)			($''$)					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
015536.7+311525	01 55 36.05	31 15 18.0	14	10.9	0.055	0.18	-0.34	0	15.9	17.3	Sey	0.135	-22.3
015546.4+071902	01 55 46.39	07 19 03.8	14	1.8	0.076	0.71	0.09	15	15.4	17.7	Sey	0.069	-20.4
015555.6+040620	01 55 55.28	04 06 19.3	10	4.8	0.094	0.40	0.42	13	15.9	17.6	Sey	0.136	-22.0
015621.6+241838	01 56 21.37	24 18 37.4	11	3.2	0.065	0.90	-0.07	0	16.3	17.0	Sey	0.155	-22.9
020348.7+295921	02 03 48.66	29 59 26.3	7	5.3	0.539	-0.96	-1.00	5	16.0	15.5	CV		
022851.6+335949	02 28 53.21	33 59 40.7	37	21.7	0.080	0.93	0.22	81	15.5	16.1			
	02 28 53.70	34 00 20.2	37	40.7	0.080	0.93	0.22	81	16.0	20.2	CL	0.19	
	02 28 51.33	33 59 10.6	37	38.5	0.080	0.93	0.22	81	16.1	17.8			
023601.9+082124	02 36 01.37	08 21 27.2	9	8.5	0.092	0.23	0.20	5	16.1	17.3	QSO	0.228	-23.5
023739.9+181945	02 37 40.49	18 19 41.8	12	9.0	0.099	1.00	0.55	0	15.9	16.4	QSO	0.168	-23.7
024214.5+074442	02 42 14.20	07 44 53.3	16	12.1	0.098	0.74	0.17	25	16.3	16.5	QSO	0.451	-25.8
033522.6+190739	03 35 22.59	19 07 28.5	8	10.5	0.281	0.98	0.44	9	15.8	17.1	QSO	0.189	-23.2
034308.0+185836	03 43 08.30	18 58 25.5	12	11.3	0.183	0.99	0.42	25	15.4	16.7	Sey	0.110	-22.4
034314.1+102941	03 43 14.26	10 29 39.3	9	2.9	0.210	-0.95	-0.01	0	16.5	16.6	WD		
035147.6+103618	03 51 47.81	10 36 07.5	9	10.9	0.095	0.90	0.00	9	16.5	17.6	Sey	0.185	-22.7
035345.9+195825	03 53 46.24	19 58 25.6	12	4.8	0.126	0.90	0.21	17	9.7	12.6	Sey	0.029	-23.7
	03 53 46.53	19 58 17.8		11.4					16.1	17.9			
040513.2+173647	04 05 13.29	17 36 43.4	10	3.8	0.097	1.00	0.59	0	16.1	20.0	Sey	0.098	-18.9
041147.1+132417	04 11 46.89	13 24 16.6	9	3.1	0.077	0.77	0.01	0	15.9	17.4	QSO	0.277	-23.8
044428.6+122113	04 44 28.77	12 21 11.6	9	2.9	0.162	0.98	0.17	6	15.2	16.2	Sey	0.089	-22.5
062334.6+644542	06 23 35.13	64 45 36.2	9	6.7	0.259	0.87	0.30	9	16.0	17.2	Sey	0.086	-21.4
062518.2+733433	06 25 16.23	73 34 38.9	9	10.2	0.180	-0.32	-0.02	14	14.5	14.8	CV		
065136.5+563732	06 51 36.66	56 37 36.7	12	4.9	0.054	0.72	-0.14	0	16.7	16.8	QSO	0.286	-24.5
	06 51 36.78	56 37 20.7		11.5					16.4	18.5			
065211.3+553436	06 52 11.62	55 34 34.0	9	3.4	0.151	0.91	0.27	10	15.2	16.8	Sey	0.064	-21.1
071006.0+500243	07 10 06.75	50 02 45.9	12	7.8	0.123	0.83	0.33	0	16.3	16.8	QSO	0.154	-23.1
071339.7+382043	07 13 40.30	38 20 39.7	8	7.8	0.120	0.75	0.12	0	14.8	16.0	QSO	0.123	-23.4
071858.2+705920	07 18 57.72	70 59 21.1	10	2.6	0.082	0.22	0.27	0	15.6	17.4	Sey	0.066	-20.6
071923.7+570840	07 19 24.28	57 08 39.8	9	4.7	0.184	0.70	0.18	9	15.4	0.7	QSO	0.175	-24.1
072220.6+732041	07 22 22.63	73 20 35.3	14	10.4	0.065	-0.29	-0.59	17	16.0	17.6	QSO	0.350	-24.1
072408.4+355309	07 24 08.82	35 53 06.2	8	5.8	0.260	0.47	-0.05	10	16.1	16.6	QSO	0.138	-23.1
072826.6+303407	07 28 26.68	30 34 12.6	12	5.7	0.069	0.55	0.27	17	16.0	17.4	Sey	0.100	-21.5
072912.9+410552	07 29 12.22	41 05 50.9	10	7.8	0.112	0.82	-0.03	14	15.9	17.1	Sey	0.103	-21.9
073152.4+280423	07 31 52.28	28 04 21.2	9	2.4	0.215	0.67	0.05	17	15.7	17.0			
	07 31 52.72	28 04 33.0	9	10.9	0.215	0.67	0.05	17	16.5	19.1	CL	0.25	
073221.5+313750	07 32 21.31	31 37 41.4	11	8.9	0.364	0.81	0.34	55	16.6	20.7	CL	0.17	
073308.7+455511	07 33 09.27	45 55 05.6	8	8.0	0.273	0.83	0.14	13	15.5	16.2	QSO	0.142	-23.5
073720.4+351752	07 37 20.94	35 17 40.9	14	12.9	0.090	0.64	0.57	0	15.8	18.9	BL can	0.213	

Table 2. continued

ROSAT name	RA	Dec	P.E	D	CR	HR1	HR2	ext	R	B	ID	z	M _B
1RXS J	(2000)	(2000)	($''$)	($''$)	(cts s ⁻¹)			($''$)					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
073735.8+430856	07 37 35.58	43 08 51.0	10	5.6	0.056	1.00	0.06	0	16.4	17.6	Sey	0.119	-22.9
074003.8+240621	07 40 03.52	24 06 15.7	11	6.5	0.077	0.54	0.13	0	15.5	17.1			
074228.1+465648	07 42 27.06	46 56 42.6	18	11.9	0.085	1.00	0.14	27	16.5	17.3	Sey	0.170	-22.8
074311.3+742926	07 43 12.57	74 29 36.0	10	11.2	0.139	0.18	0.50	11	16.2	17.0	QSO	0.332	-24.6
074759.2+205229	07 47 59.16	20 52 26.5	9	2.6	0.112	0.62	0.28	0	15.3	15.8	QSO	0.156	-24.1
074906.2+451039	07 49 06.51	45 10 33.9	9	6.1	0.109	0.79	0.56	6	15.8	16.1	QSO	0.192	-24.3
075026.6+270726	07 50 26.36	27 07 16.7	11	9.8	0.066	0.40	0.10	0	16.3	17.6	Sey	0.154	-22.3
075039.5+624205	07 50 40.40	62 42 12.4	9	9.7	0.091	0.23	0.32	0	16.5	17.9	Sey	0.194	-22.5
075124.3+173044	07 51 25.08	17 30 51.1	12	13.2	0.151	0.76	0.07	30	15.7	19.4	CL	0.186	
075408.7+431611	07 54 07.97	43 16 10.7	8	8.0	0.122	0.48	0.19	0	16.5	17.4	QSO	0.350	-24.3
075409.5+512436	07 54 09.65	51 24 28.7	26	7.4	0.054	0.43	0.67	50	17.0	17.5	QSO	0.331	-24.1
	07 54 11.95	51 24 16.8		29.9					15.7	17.3			
075634.7+362232	07 56 34.65	36 22 14.8	12	17.2	0.060	0.43	0.08	0	16.7	17.3	QSO	0.884	-26.7
	07 56 34.90	36 22 42.6		10.9				0	16.0	16.9			
075910.0+115152	07 59 10.43	11 51 56.4	10	7.7	0.154	-0.23	-0.25	0	15.0	16.7	Sey	0.050	-20.7
080132.3+473618	08 01 31.96	47 36 15.8	8	4.1	0.317	0.45	0.29	0	15.2	15.9	QSO	0.157	-24.1
080358.9+433248	08 03 59.24	43 32 58.1	12	10.7	0.071	-0.11	0.29	9	17.2	17.7	QSO	0.451	-24.6
	08 03 59.04	43 32 36.8		11.3					16.1	17.7			
080534.6+543132	08 05 34.84	54 31 30.2	8	2.8	0.163	0.09	-0.01	0	14.9	15.5	QSO	0.406	-26.5
080548.5+112617	08 05 48.05	11 26 06.1	8	12.7	0.208	-0.45	0.56	0	15.1	16.8			
	08 05 48.84	11 26 17.2	8	5.0	0.208	-0.45	0.56	0	16.5	17.4	Sey	0.144	-22.3
080625.5+593105	08 06 25.87	59 31 06.6	8	3.2	0.190	0.74	0.27	11	16.0	17.9	BL		
080639.9+724831	08 06 39.00	72 48 20.1	27	11.6	0.148	0.18	0.39	35	15.9	17.1	Sey	0.099	-21.8
080727.2+140534	08 07 27.31	14 05 37.1	13	3.5	0.147	0.26	0.61	0	14.6	16.6	Sey	0.074	-21.6
081010.6+351718	08 10 12.82	35 17 21.7	35	27.4	0.091	0.43	0.58	55	15.2	17.6	CL	0.085	
	08 10 12.23	35 17 18.3	35	20.0	0.091	0.43	0.58	55	15.8	18.4			
081021.3+421657	08 10 22.51	42 16 41.9	26	20.2	0.138	1.00	0.28	91	16.1	18.3	CL	0.065	
	08 10 21.33	42 17 12.6		15.6					16.4	19.2			
081237.9+435636	08 12 37.80	43 56 34.9	13	1.5	0.098	0.69	0.12	22	15.9	17.4	Sey	0.183	-22.9
081502.4+525304	08 15 01.81	52 52 55.3	8	10.2	0.160	0.27	0.24	0	15.6	16.6	Sey	0.126	-22.9
081651.4+180252	08 16 51.13	18 02 49.5	9	4.6	0.267	0.36	0.10	11	16.2	17.8	Sey	0.158	-22.1
081718.6+520200	08 17 18.54	52 01 47.7	11	12.3	0.072	0.59	0.18	0	15.8	17.1	Sey	0.040	-19.8
081738.0+242333	08 17 38.33	24 23 29.7	12	5.6	0.074	0.60	0.34	0	16.3	17.7	QSO	0.283	-23.5
082100.4+075146	08 21 00.83	07 51 26.4	20	20.6	0.195	0.80	0.26	65	16.3	18.9	CL	0.110	
082556.9+041504	08 25 57.78	04 14 47.9	19	20.8	0.107	0.53	0.41	21	16.1	19.3	CL	0.226	
082633.1+074259	08 26 33.53	07 42 48.0	12	12.7	0.089	-0.95	0.00	0	16.4	17.3	QSO	0.312	-24.2
082814.5+415359	08 28 14.20	41 53 51.0	10	8.7	0.089	0.75	0.24	10	15.8	18.9	BL can	0.223	
082904.3+074335	08 29 04.63	07 43 39.7	18	6.8	0.057	0.54	0.61	0	15.4	17.1			

Table 2. continued

ROSAT name	RA	Dec	P.E	D	CR	HR1	HR2	ext	R	B	ID	z	M _B
1RXS J	(2000)	(2000)	($''$)	($''$)	(cts s ⁻¹)			($''$)					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
082942.2+415442	08 29 42.64	41 54 36.4	12	7.5	0.094	0.85	-0.01	14	16.1	18.3	Sey	0.126	-21.2
083737.3+254746	08 37 37.11	25 47 49.6	9	4.4	0.065	1.00	0.24	0	16.1	18.0	Sey	0.080	-20.4
083820.6+241025	08 38 20.02	24 10 25.5	13	8.0	0.161	-0.05	0.19	0	17.4	18.8	Sey	0.043	-18.1
	08 38 21.29	24 10 40.0		17.7					15.5	17.8			
084000.4+443752	08 40 00.13	44 37 37.7	26	14.6	0.081	-0.07	0.32	0	15.8	17.1			
084026.2+033316	08 40 25.47	03 33 02.0	13	17.8	0.209	0.09	0.03	28	15.3	16.0	Sey	0.060	-21.8
084302.0+030226	08 43 02.93	03 02 18.8	12	15.7	0.103	-0.32	0.23	12	15.8	15.9	QSO	0.512	-26.6
084622.3+031318	08 46 22.56	03 13 22.4	10	5.9	0.184	0.03	0.13	0	15.9	16.9	Sey	0.107	-22.2
084658.3+704452	08 46 56.94	70 44 36.1	17	17.3	0.071	0.31	0.25	26	15.6	19.0	CL	0.181	
084829.3+811145	08 48 27.81	81 11 47.9	10	4.5	0.118	-0.50	-0.32	10	15.6	18.7	BL can	0.175	
084856.8+584150	08 48 55.97	58 41 54.1	16	7.6	0.066	0.64	-0.22	19	16.4	17.9	Sey	0.134	-21.7
084918.7+531806	08 49 17.31	53 17 55.7	12	16.2	0.056	0.35	0.53	9	15.6	16.9	Sey	0.112	-22.3
085233.3+422539	08 52 33.82	42 25 45.0	11	8.3	0.105	-0.24	-0.36	0	16.3	17.9	Sey	0.137	-21.7
085358.8+770054	08 53 59.44	77 00 54.6	8	2.2	0.192	-0.10	0.30	0	15.4	17.0	Sey	0.106	-22.1
085443.8+401912	08 54 43.65	40 19 07.4	8	4.9	0.094	0.53	-0.05	0	15.6	16.6	QSO	0.152	-23.3
085706.2+621050	08 57 05.18	62 10 47.6	10	7.5	0.086	0.79	0.48	13	16.0	19.1	Sey	0.160	-20.9
085820.6+642100	08 58 20.56	64 20 48.6	13	11.4	0.072	0.56	0.18	14	16.1	17.9	Sey	0.115	-21.3
085902.0+484611	08 59 02.84	48 46 09.0	7	8.5	0.645	-0.13	0.09	7	14.3	15.0	QSO	0.083	-23.5
190910.3+665222	19 09 10.85	66 52 21.2	7	3.4	0.085	0.09	0.02	11	16.4	17.3	QSO	0.191	-23.0
193708.3+660821	19 37 08.16	66 08 21.2	7	0.9	0.147	0.87	0.17	11	15.3	16.7			
193929.8+700752	19 39 29.37	70 07 49.2	7	3.6	0.263	0.87	0.13	14	15.4	16.1	QSO	0.116	-23.1
194017.2+680738	19 40 17.24	68 07 29.9	12	8.1	0.061	0.97	0.23	38	15.5	20.1	CL	0.17	
194639.7+704552	19 46 40.58	70 45 57.7	8	7.2	0.081	0.95	0.35	10	15.2	16.9			
	19 46 38.14	70 45 56.1		8.7					13.4	15.0	CV		
210452.8+140134	21 04 53.36	14 01 29.8	20	8.9	0.141	1.00	0.18	77	16.5	20.0	CL	0.20	
	21 04 53.14	14 01 30.3		6.0					14.6	18.2			
210550.5+041435	21 05 50.86	04 14 38.8	11	6.5	0.054	0.80	-0.12	0	16.4	17.8	Sey	0.139	-21.9
212654.3+112403	21 26 53.95	11 24 00.8	9	5.6	0.156	0.69	0.00	15	15.4	16.7	Sey	0.096	-22.2
214309.6+153658	21 43 09.24	15 37 06.1	11	4.6	0.104	0.90	0.22	0	16.2	16.7	QSO	0.385	-25.3
214655.2+092102	21 46 54.12	09 20 48.6	21	20.9	0.072	0.90	-0.04	36	16.4	16.7	QSO	0.984	-27.5
214923.8+092921	21 49 24.22	09 29 27.9	15	9.3	0.068	0.76	-0.15	16	16.3	16.5			
215853.4+244206	21 58 52.21	24 42 14.4	16	18.3	0.070	0.40	0.00	0	15.3	15.9			
215912.7+095247	21 59 12.35	09 52 43.4	8	6.3	0.245	0.49	0.15	0	14.9	16.2	Sey	0.102	-22.7
	21 59 12.35	09 52 42.2		7.1					15.2	16.9			
221513.4+171524	22 15 14.01	17 15 23.9	10	8.7	0.113	0.06	0.27	10	15.6	17.7			
221537.8+290239	22 15 36.85	29 02 36.0	15	12.8	0.112	0.86	0.09	36	16.2	16.5	QSO	0.229	-24.3
221631.2+290025	22 16 31.29	29 00 16.1	10	6.8	0.099	0.92	0.10	16	15.1	16.1	CV		
221918.8+120757	22 19 18.54	12 07 52.7	9	5.7	0.248	0.04	-0.45	14	15.7	17.0	Sey	0.082	-21.5

Table 2. continued

ROSAT name	RA	Dec	P.E	D	CR	HR1	HR2	ext	R	B	ID	z	M _B
1RXS J	(2000)	(2000)	(")	(")	(cts s ⁻¹)			(")					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
221944.6+212054	22 19 45.25	21 20 48.7	10	10.5	0.080	0.34	0.21	0	15.6	17.0	BL can	0.20	
222537.5+225917	22 25 37.55	22 59 26.3	12	9.3	0.060	0.39	0.23	9	16.1	16.1	QSO	0.173	-24.1
222657.0+254946	22 26 55.92	25 50 09.1	25	27.3	0.101	1.00	-0.12	82	15.7	19.7	CL	0.17	
	22 26 56.06	25 49 39.1		14.4					17.3	18.0			
222846.3+333500	22 28 46.34	33 35 07.8	8	7.8	0.113	0.66	0.33	5	14.9	15.9	Sey	0.090	-22.8
222934.3+305720	22 29 34.15	30 57 12.1	12	8.1	0.073	0.79	-0.02	19	16.4	17.1	QSO	0.319	-24.4
223019.5+163114	22 30 19.67	16 31 12.4	8	3.0	0.159	0.54	0.26	8	15.0	16.0	Sey	0.084	-22.5
224621.7+314206	22 46 21.68	31 42 07.6	8	1.6	0.146	0.83	-0.07	4	15.8	17.1	Sey	0.145	-22.6
224939.6+110016	22 49 39.57	11 00 29.2	9	13.2	0.184	0.44	0.07	0	14.8	15.7	Sey	0.084	-22.8
225148.5+341937	22 51 47.79	34 19 30.3	7	11.0	0.254	0.83	0.04	10	16.3	16.8	Sey	0.132	-22.8
225209.6+264236	22 52 09.37	26 42 40.7	9	5.6	0.133	0.45	-0.04	0	15.2	16.0	Sey	0.069	-22.1
225453.7+241449	22 54 53.54	24 14 41.0	14	8.3	0.064	-0.27	0.16	0	16.1	17.8			
	22 54 55.03	24 14 45.3		18.6					13.5	16.3	M		
225639.4+261846	22 56 39.18	26 18 43.1	9	4.1	0.055	0.77	0.22	0	16.2	18.1	Sey	0.176	-22.1
230325.2+075642	23 03 25.03	07 56 43.6	15	2.9	0.165	0.68	0.32	41	16.2	18.9	CL	0.16	
230328.0+144341	23 03 27.92	14 43 49.0	15	8.1	0.109	0.96	0.16	11	14.7	16.4	Sey	0.080	-22.0
230949.6+213523	23 09 49.28	21 35 19.0	9	6.0	0.212	0.20	0.30	18	15.7	17.9	CV		
231107.7+113812	23 11 06.14	11 38 29.2	29	28.4	0.065	1.00	0.61	62	16.5	20.2	CL	0.26	
231456.0+224325	23 14 55.89	22 43 23.4	9	2.2	0.109	0.82	0.10	10	15.7	16.5	QSO	0.171	-23.6
231517.5+182825	23 15 17.08	18 28 14.4	11	12.2	0.085	0.72	0.64	0	15.0	16.5	Sey	0.104	-22.5
232339.1+090842	23 23 38.98	09 08 50.6	23	8.8	0.128	0.47	0.24	71	14.8	19.9	CL	0.21	
232554.6+215310	23 25 54.24	21 53 14.2	7	6.5	0.555	0.63	0.15	5	15.5	15.8	QSO	0.120	-23.5
232841.4+224853	23 28 41.41	22 48 47.9	19	5.1	0.082	0.72	-0.01	24	16.4	18.0	Sey	0.129	-21.5
232953.9+062814	23 29 54.38	06 28 10.2	11	8.1	0.064	0.46	0.84	0	15.6	16.6	CV		
233152.6+195735	23 31 51.98	19 56 48.0	43	47.8	0.993	0.05	0.11	0	13.6	15.1	M		
233315.8+225539	23 33 15.61	22 55 49.5	26	10.8	0.120	0.96	0.17	86	16.4	18.6	CL	0.07	
234456.7+091149	23 44 57.45	09 11 35.3	13	17.6	0.637	0.96	0.18	106	13.5	15.9	CL	0.04	
234728.8+242743	23 47 28.77	24 27 45.8	7	2.8	0.262	0.75	0.26	10	15.9	16.5	QSO	0.159	-23.5
234734.6+271910	23 47 35.24	27 19 00.6	13	12.7	0.071	0.93	0.45	0	15.9	16.1	QSO	0.646	-27.0
235034.7+292924	23 50 35.65	29 29 19.7	12	13.0	0.122	0.87	-0.04	0	16.0	19.5	CL	0.153	
235152.7+261938	23 51 52.87	26 19 32.1	8	6.3	0.338	0.56	0.17	9	14.9	16.6	Sey	0.040	-21.3
235754.3+132418	23 57 53.82	13 24 09.6	9	11.0	0.235	0.13	0.03	14	15.3	15.8	QSO	0.115	-23.4

The abbreviations have the following meanings:

“QSO”: quasi-stellar object (unresolved or resolved object with $M_B < 23$ showing a Seyfert 1 spectrum).

“Sey”: Seyfert galaxy.

“BL”: BL Lac object.

“BL can”: BL Lac candidate.

“CL”: cluster of galaxies.

“WD”: white dwarf.

“CV”: cataclysmic variable star.

“M”: M star.

Column (13): Average redshift for extragalactic counterpart.

Column (14): Absolute B magnitude calculated with the formula used by Véron-Cetty & Véron (1996) for emission line AGN.

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