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Nine newly discovered bright low-redshift quasars from RASS

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Abstract. By using the CCD detector and Cassegrain spectrograph of the 2.16 m telescope at Beijing Astronomical Observatory, we are carrying out optical identifications of the X-ray sources selected from the ROSAT All-Sky Survey Bright Source Catalogue. We present here the discovery of 9 bright low-redshift quasars.

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

1. Introduction

During the ROSAT All-Sky Survey (RASS) about 80 000 X-ray sources with a detection likelihood $\geq$ 10 were found (Voges 1992; Voges et al. 1994; Voges et al. 1996b, 1997), from which 18 811 sources were compiled in the ROSAT Bright Source Catalogue (RASS-BSC) (Voges et al. 1996a,b; Voges et al. 1997). Most of them are newly discovered X-ray sources and more than 65% of the objects were previously unknown (Brinkmann et al. 1995; Bade et al. 1998). The optical spectroscopic studies of these RASS sources are essential for understanding them more clearly. We are performing a program to identify unknown RASS sources at high galactic latitude ($|b| \geq 20°$) in the northern hemisphere ($\delta \geq 3°$) and whose likely optical counterparts have R magnitudes between 13.5 and 16.5. About 60 quasars were identified independently through low dispersion spectroscopic observations in 1996 and 1997 (Wei et al. 1996, 1997). In this paper we report on the discovery of 9 bright low-redshift quasars (hereafter BLRQs) with B magnitude equal to or less than 17.0.

In Sect. 2, the sample selection is introduced. The observations and results are presented in Sect. 3.

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Table 1. Journal of observations

ROSAT name	Obs. Date	Exposure (sec)	dispersion [Å mm^{-1}]
1RXS J071339.7+382043	Jan. 28 1997	800	200
1RXS J073308.7+455511	Jan. 2 1997	1200	200
1RXS J092748.9+403838	Jan. 1 1997	3100	200
1RXS J101031.1+255959	Dec. 19 1996	1000	200
1RXS J104111.5+282812	Jan. 6 1997	1800	200
1RXS J111754.9+263413	Jan. 30 1997	1800	200
1RXS J120347.5+520748	Dec. 19 1996	600	200
1RXS J120423.7+433059	Jan. 2 1997	2100	200
1RXS J122542.3+205503	Dec. 18 1996	1200	200

Table 2. X-ray characteristic of the new quasars

ROSAT name	Error radius (arcsec)	Cnt rate (cts/s)	$HR1$	$HR2$
1RXS J071339.7 + 382043	8	0.120	0.75	0.12
1RXS J073308.7 + 455511	8	0.273	0.83	0.14
1RXS J092748.9 + 403838	9	0.190	−0.25	−0.06
1RXS J101031.1 + 255959	14	0.054	−0.57	0.38
1RXS J104111.5 + 282812	8	0.221	−0.26	0.15
1RXS J111754.9 + 263413	12	0.068	−0.85	0.00
1RXS J120347.5 + 520748	7	0.361	−0.36	0.08
1RXS J120423.7 + 433059	9	0.091	−0.48	−0.80
1RXS J122542.3 + 205503	10	0.329	−0.63	−0.20

2. Sample selection

Our sample is selected from RASS-BSC according to the following criteria:

1. Declination $\delta \geq 3°$.
2. Galactic latitude $|b| \geq 20°$.
3. Optical counterparts within a circle with radius $r = r' + 5''$, where r' is the RASS position error given by Voges et al. (1996b).

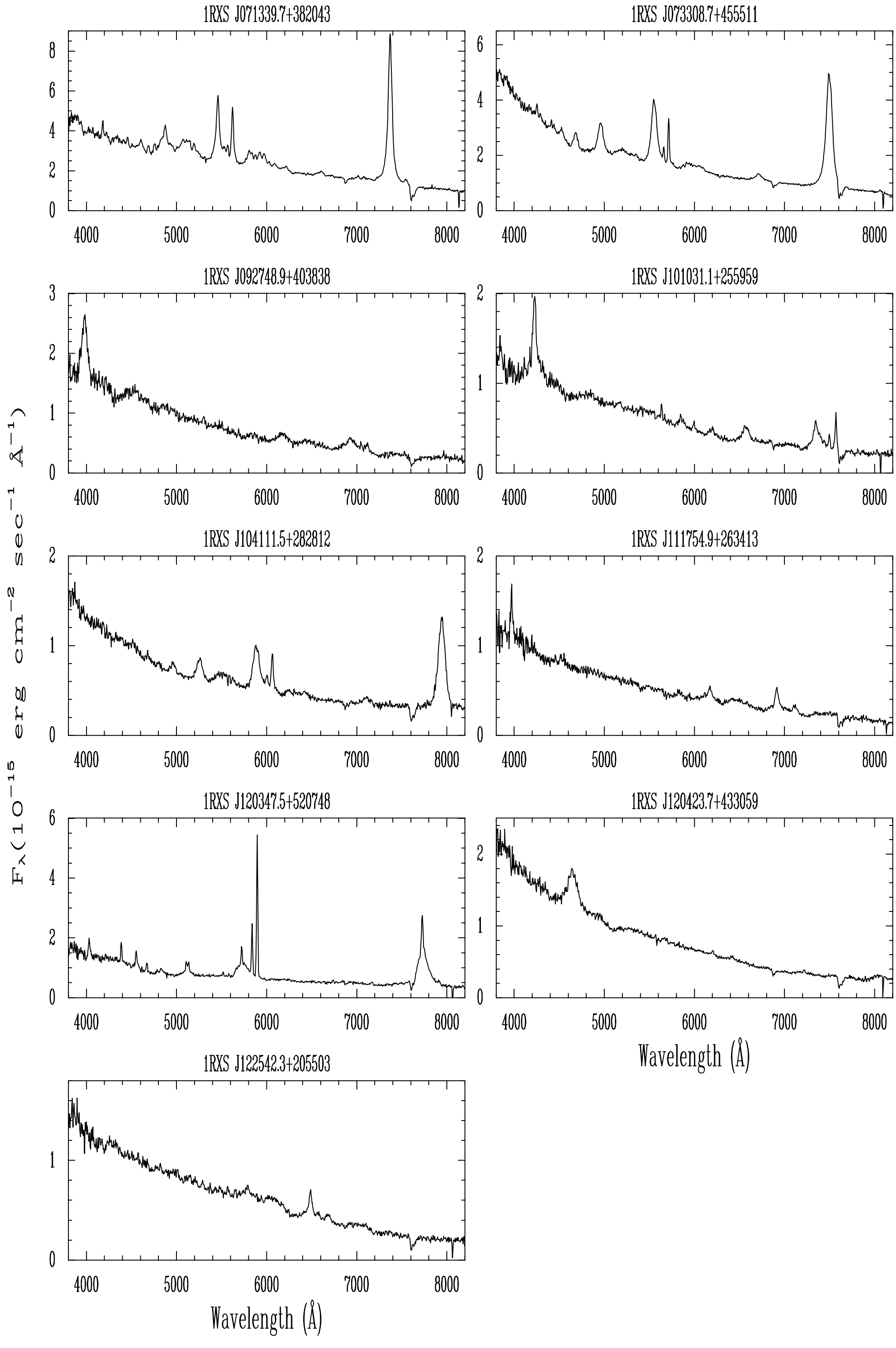

Fig. 1. Spectra of the new quasars

Table 3. Optical properties of the new quasars

ROSAT name	RA (2000)	DEC (2000)	D_{o-x} (arcsec)	R	B	z	M_B	Comments
1RXS J071339.7+382043	07 13 40.30	38 20 39.7	9.6	14.8	16.0	0.123	−23.4	H_δ, H_γ, FeII, H_β, HeI, H_α, [OII], [NeIII], [OIII]
1RXS J073308.7+455511	07 33 09.27	45 55 05.6	10.1	15.5	16.2	0.142	−23.5	H_δ, H_γ, FeII, H_β, HeI, H_α, [OII], [NeIII], [OIII]
1RXS J092748.9+403838	09 27 49.07	40 38 31.7	6.8	16.2	16.4	0.423	−25.7	MgII, H_γ, H_β, [OII], [OIII]
1RXS J101031.1+255959	10 10 30.55	25 59 48.7	13.2	16.3	16.7	0.512	−25.8	MgII, H_δ, H_γ, H_β, [OII], [NeIII], [OIII]
1RXS J104111.5+282812	10 41 11.95	28 28 04.7	7.7	16.1	16.8	0.210	−23.8	H_δ, H_γ, FeII, H_β, HeI, H_α, [NeIII], [OIII]
1RXS J111754.9+263413	11 17 54.33	26 34 16.4	9.2	16.1	16.9	0.422	−25.2	MgII, H_γ, H_β, [OIII]
1RXS J120347.5+520748	12 03 47.71	52 07 49.5	3.5	16.0	16.8	0.177	−23.4	H_δ, H_γ, HeII, H_β, H_α, [NeV], [NeIII], [OIII]
1RXS J120423.7+433059	12 04 24.03	43 30 56.6	5.5	15.6	16.5	0.663	−26.6	MgII, H_γ, [OII]
1RXS J122542.3+205503	12 25 41.89	20 55 03.7	6.2	16.1	16.5	0.334	−25.1	H_γ, H_β, [OIII]

4. Optical counterparts with R magnitudes between 13.5 and 16.5, where R magnitude was derived from USNO-A1.0[1].
5. $\log C \geq -0.4\,R + 4.9$.
   where C is the X-ray count rate of RASS source and R is the R magnitude of possible counterpart. 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). However, X-ray flux is difficult to evaluate before optical identification. In spite of the absorption by the column density $N_{\rm H}$ of cold material X-ray count rate is roughly proportional to X-ray flux, so X-ray flux in the X-ray-to-optical flux ratio criterion can be replaced by X-ray count rate, i.e., $\log(f_{\rm X}/f_{\rm O}) \propto \log C + 0.4\,R +$ constant, where we use the R magnitude flux to represent the optical flux. According to our statistical analysis of known RASS-BSC X-ray sources, we found there is an apparent gap between Galactic stars and extragalactic objects. Emission line AGNs concentrate on the region: $\log C \geq -0.4\,R + 4.9$. Thus choosing $\log C \geq -0.4\,R + 4.9$ as preselecting AGNs criterion would be efficient. Details of the criterion construction have been described in Cao et al. (1998);
6. No association with objects in the Galactic and extragalactic catalogues compiled in the SIMBAD and NED database.

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

3. Spectroscopic observations and results

The spectroscopic observations were made in several observing runs in 1996 and 1997 with the 2.16 m telescope of the United Laboratory of Optical Astronomy, Chinese Academy of Sciences at Xinglong Station, Beijing Astronomical Observatory (BAO). The spectra were obtained with the OMR spectrograph equipped with a Tektronix CCD (1024 × 1024 pixels with 24 microns per pixel) at a dispersion of 200 Å mm^{-1} or 400 Å mm^{-1}. The 400 Å mm^{-1} grating was not used if one believes Table 1. The spectral coverage was 3800 − 8200 Å. The journal of observations is given in Table 1.

The data reduction was performed by using the IRAF program package. The CCD reductions included bias subtraction, flatfield correction and cosmic-ray removal. Spectra of a He-Ne-Ar or Fe-Ar lamp were taken to get an absolute wavelength scale. The flux calibration was derived with 2 to 3 observations of KPNO IIDS standard Stars (Strom 1979) per night. The atmospheric extinction was corrected by using the mean extinction coefficients of Xinglong Station, which were measured by BATC multicolor survey (Yan 1995).

The X-ray characteristics and optical properties of the 9 BLRQs are summarized in Tables 2 and 3, and their spectra are shown in Fig. 1. Position error radius, count rates, hardness ratios 1 & 2 listed in Table 2 are from RASS-BSC. Hardness ratios are defined as:

$$HR1 = \frac{H - S}{H + S}$$

$$HR2 = \frac{H_1 - H_2}{H_1 + H_2}$$

where H, S, H_1, and H_2 are the count rates in the hard H-band (0.4 − 2.4 keV), the soft S-band (0.07 − 0.4 keV), the hard H_1-band (0.4 − 1.0 keV) and the hard H_2-band (1.0 − 2.4 keV) respectively. The coordinates given in

Table 3 were obtained from USNO-A1.0. We applied these coordinates to the Digitized Sky Survey[2] and did not find any ambiguous identifications of the objects, so we do not give the finding charts of the 9 BLRQs. The average redshifts were usually determined from two or more emission lines. The B and R magnitudes were obtained from USNO-A1.0 and have an accuracy between 0.25 and 0.40 magnitudes depending on the declination (Monet et al. 1996). The absolute B magnitudes were calculated by the same formula used by Véron-Cetty & Véron (1996) under the assumption of $H_0 = 50\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ and $q_0 = 0$. The $D_{\mathrm{x-opt}}$ listed in Table 3 is the angular separation between the X-ray centroïd and the optical countpart in arcseconds.

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