Astron. Astrophys. 362, 263–267 (2000)

ASTRONOMY AND ASTROPHYSICS

Research Note

New cataclysmic variables from the RASS

X.J. Jiang[1,2], **D. Engels**[3], **J.Y. Wei**[1,2], **F. Tesch**[3], **and J.Y. Hu**[1,2]

[1] Beijing Astronomical Observatory, Chinese Academy of Sciences, Beijing 100012, P.R. China
[2] National Astronomical Observatories, Chinese Academy of Sciences
[3] Hamburger Sternwarte, Gojenbergsweg 112, 21029 Hamburg, Germany

Received 27 June 2000 / Accepted 7 August 2000

Abstract. We report on a follow-up study of 15 CV candidates, which were discovered by the ROSAT All-Sky Survey and have been identified on the objective prism plates of the Hamburg Quasar Survey so far. For all objects we could obtain low resolution optical spectra confirming 12 CVs. The misidentifications are two quasars and an M-dwarf.

Key words: surveys – X-rays: stars – X-rays: galaxies – stars: novae, cataclysmic variables – stars: binaries: spectroscopic

1. Introduction

Cataclysmic variables (CVs) consist of a white dwarf accreting matter from a low mass companion star in a semi-detached system. Depending on the mass transfer rate and on the magnetic field of the white dwarf, the matter leaving the inner Lagrangian point may either come from an accretion disc or flow directly toward the white dwarf pole following the magnetic field lines. Most of the CVs were found optically due to their large brightness variations. However, there are a large number of CVs having low outburst amplitudes or long outburst periods, which are easy to be lost in variable star surveys.

The northern Hamburg objective prism survey (Hamburg Quasar Survey (HQS), Hagen et al. 1995) is a rich source of CV candidates due to their strong emission-line spectrum in quiescent state, which is easily recognized in the low resolution prism spectra. For only a few follow-up spectroscopy has been made up to now (Billington et al. 1996; Fiedler et al. 1997; Dobrzycka et al., 1998; Reimers et al. 1999; Gänsicke et al. 2000, Reimers & Hagen 2000). We report here our results of first follow-up spectroscopic observations of CV candidates, which were discovered by identifying X-ray sources from the ROSAT All-Sky Survey (RASS, Voges et al. 1992) on the HQS objective prism plates. More detailed photometric and spectroscopic observations will be carried out in the near future.

2. Sample selection and observations

Our candidates for new cataclysmic variables were selected from the Hamburg/RASS Database of Optical Identifications. This database contain likely optical counterparts to X-ray sources discovered by the RASS identified on the HQS objective prism plates. Part of this database is contained in the Hamburg/RASS Catalogue (Bade et al. 1998), which comprises optical counterparts to X-ray sources compiled in the ROSAT Bright Source Catalogue (Voges et al. 1999). In total we found 15 CV candidates, which were not listed in the SIMBAD database as of July 1998.

The follow-up spectroscopic observations of 14 candidates were made with the 2.16 m reflector at Xinglong Station, Beijing Astronomical Observatory from July 1998 through October 1999. We took low resolution spectra with the OMR spectrograph, using a Tektronix 1024 CCD as a detector. Two gratings of 300 g mm^{-1} and 150 g mm^{-1} were employed in order to get large wavelength coverage. The gratings give a dispersion of $\approx$4.8 Å pixel^{-1} and $\approx$9.6 Å pixel^{-1} respectively. All observations were obtained at airmass less than 1.5 and under good atmospheric condition. The raw two-dimensional data were reduced following standard procedures using the IRAF program package.

The faintest candidate 1RXS 143703.5+234236 was observed on 2000 March 16 with the 2.2m telescope on Calar Alto / Spain equipped with the CAFOS spectrograph. We used the G200 grism and a 2″ slitwidth giving a spectral resolution of 16 Å. The weather was non-photometric. Data reduction included spectrum extraction, rebinning and correction for the instrumental response.

A detailed overview of the candidates and the log of spectroscopic observations are given in Table 1.

3. Results

The spectra obtained are shown in Fig. 1. In 12 cases we could confirm the candidates as cataclysmic variables, while the remaining three objects turned out to be two quasars and one active M-dwarf. A finding chart (Fig. 2) is shown for 1RXS 013126.2+360241, which appears double in North-South direction. The northern component is the CV counterpart, while the southern one is a normal G-type star. The HQS brightness B1 of 1RXS 013126.2+360241 given in Table 1 includes contam-

Table 1. Details of the candidates and log of the spectroscopic observations

Candidate	RASS-BSC name (1RXS J)	RA[a] (2000)	Dec[a] (2000)	B1[b]	B2[c]	B3[d]	Obs. date	dispersion (Å pixel^{-1})	exposure (Sec.)
RX J01314+3602	013126.2+360241	01 31 25.9	+36 02 30	16.5	–	18.9	1999 Oct 18	4.8	3600
RX J01468+3152	014650.1+315229	01 46 48.4	+31 52 25	17.7	16.8	18.6	1998 Sep 17	4.8	3600
RX J02038+2959	020348.7+295921	02 03 48.6	+29 59 27	15.8	15.1	16.3	1999 Jan 19	9.6	1800
RX J05583+6753		05 58 18.0	+67 53 46	17.0	16.6	16.3	1999 Jan 18	4.8	3200
RX J07570+6306	075700.5+630602	07 57 01.4	+63 06 02	18.2	16.5	17.2	1999 Jan 18	4.8	3600
RX J09098+1849	090950.6+184956	09 09 50.6	+18 49 48	16.4	15.8	17.2	1999 Jan 18	4.8	2600
RX J09158+0900	091552.3+090056	09 15 51.8	+09 00 51	14.1	14.7	16.1	1999 Jan 18	4.8	2600
RX J09445+0357	094432.1+035738	09 44 31.8	+03 58 07	16.3	16.1	17.1	1999 Jan 26	4.8	3000
RX J10204+5304	102027.1+530439	10 20 26.7	+53 04 33	17.0	16.0	17.5	1999 Jan 18	4.8	2400
RX J13086+7026		13 08 45.9	+70 26 18	18.7	17.0	19.2	1999 Apr 13	9.6	3600
RX J14370+2342	143703.5+234236	14 37 03.3	+23 42 28	16.5	18.8	–	2000 Mar 16	4.4	1800
RX J14506+6403	145035.5+640328	14 50 38.4	+64 03 29	17.1	15.8	18.9	1999 Apr 15	9.6	1500
RX J15542+2721	155412.7+272143	15 54 12.4	+27 21 51	16.8	15.9	18.5	1999 Apr 12	4.8	2400
RX J16101+0352	161008.0+035222	16 10 07.5	+03 52 33	17.0	15.8	18.8	1999 Apr 12	4.8	3600
RX J23137+2117		23 13 46.5	+21 17 31	19.3	17.9	18.8	1998 Sep 17	4.8	2400

[a] all coordinates are from the USNO-A2.0 catalogue (Monet et al. 1999), except those of RX J01314+3602, which were measured on the direct plates of the HQS and have an accuracy of 2 $''$.
[b] B magnitude listed in the Hamburg/RASS Database with an accuracy of $\pm$ 0.5 magnitude.
[c] B magnitude from USNO-A2.0 with an accuracy of $\pm$ 0.25 magnitude (Monet et al. 1999). [d] B magnitude measured from our slit spectra with an accuracy of $\pm$ 0.8 magnitude.

ination of the G-type star because the objective prism spectra overlap. For the remaining objects finding charts are omitted, as no confusion with neighboring objects is possible.

All CVs, except one, display strong emission lines, as expected. 1RXS 155412.7+272143 shows at least H_α and H_β in emission and has a very blue continuum. Thus, the CV classification is secure in all these cases.

For most of them also considerable variability is evident from our spectra and the photographic data available (Table 1). The most spectacular variation was recorded for 1RXS 143703.5+234236, which was observed by the HQS with a brightness of B=16.5 on July 23, 1990. On a second plate taken on March 3, 1995 the object is not visible, implying B$>$18.5 consistent with the brightness listed in the USNO-A2.0 catalogue. The apparent brightness variations of the other objects following from Table 1 need independent confirmation in each case. Although expected, they may be due to calibration inconsistencies. The brightness calibrations of the HQS and of the USNO catalogue are not compatible, but the reasons for the deviations are yet not understood. The brightnesses derived from the slit spectra almost always are fainter than the brightnesses from the other two sources, implying guiding error during the observations.

A few of the new CVs presented here, were studied independently from us by other groups. 1RXS 020348.7+295921 has been identified as long period AM Herculis system (Thomas et al. 1998; Schwarz et al. 1998), while 1RXS 075700.5+630602 is a short period intermediate polar studied by Tovmassian et al. (1998). 1RXS 143703.5+234236 and 161008.0+035222 are part of the ROSAT Bright Survey (Schwope et al. 2000). Gänsicke et al. (2000) recently obtained a lightcurve for 1RXS 090950.6+184956 and classified this object as dwarf nova with a 4.2hr period. 1RXS 145035.5+640328 showed an optical burst in 2000 May and is classified by Nogami et al. (2000) as SU Uma-type dwarf nova.

As evident from the red part of their spectra, the spectral type of the low mass companions of 1RXS 155412.7+272143 and 1RXS 161008.0+035222 are M4 and M5 respectively. Also 1RXS 090950.6+184956 shows signatures of an M-type companion.

Our confirmation rate of the X-ray selected CVs is 80%. Including the CVs known before this rate would increase to 90%. This seems to be high, but the objective prism spectra of CV candidates are so conspicuous (cf. Bade et al. 1998, their Fig. 2) that some comments on the three "misidentifications" are justified. First, the M-dwarf RX J23137+2117 was wrongly classified in Bade et al. (1998), as also the objective prism spectra are consistent with a very red object. The remaining objects are quasars and were, because of different reasons, mistakenly classified as CV candidates.

1RXS 014650.1+315229 is a quasar (z=0.495, $M_B = -25$ – -23 for H_0=65, q_0=0.1) with a remarkable brightness variation and a strong Mg II λ2708 emission line visible in the objective prism spectrum. According to two HQS observations the quasar varied by 0.6 mag (B=17.7 on Nov 2, 1991 and B=18.3 on Nov 19, 1992) and we verified the significance of this brightness difference by comparison with neighboring objects on the plates. In the USNO-A2.0 catalogue B=16.8 is listed. Photometric monitoring of this QSO is required to confirm the large brightness variation implied especially from the USNO-A2.0 data.

The other quasar RX J13086+7026 (z=0.610 and $M_B = -24.8$) has a strong redshifted Mg II line, which was consid-

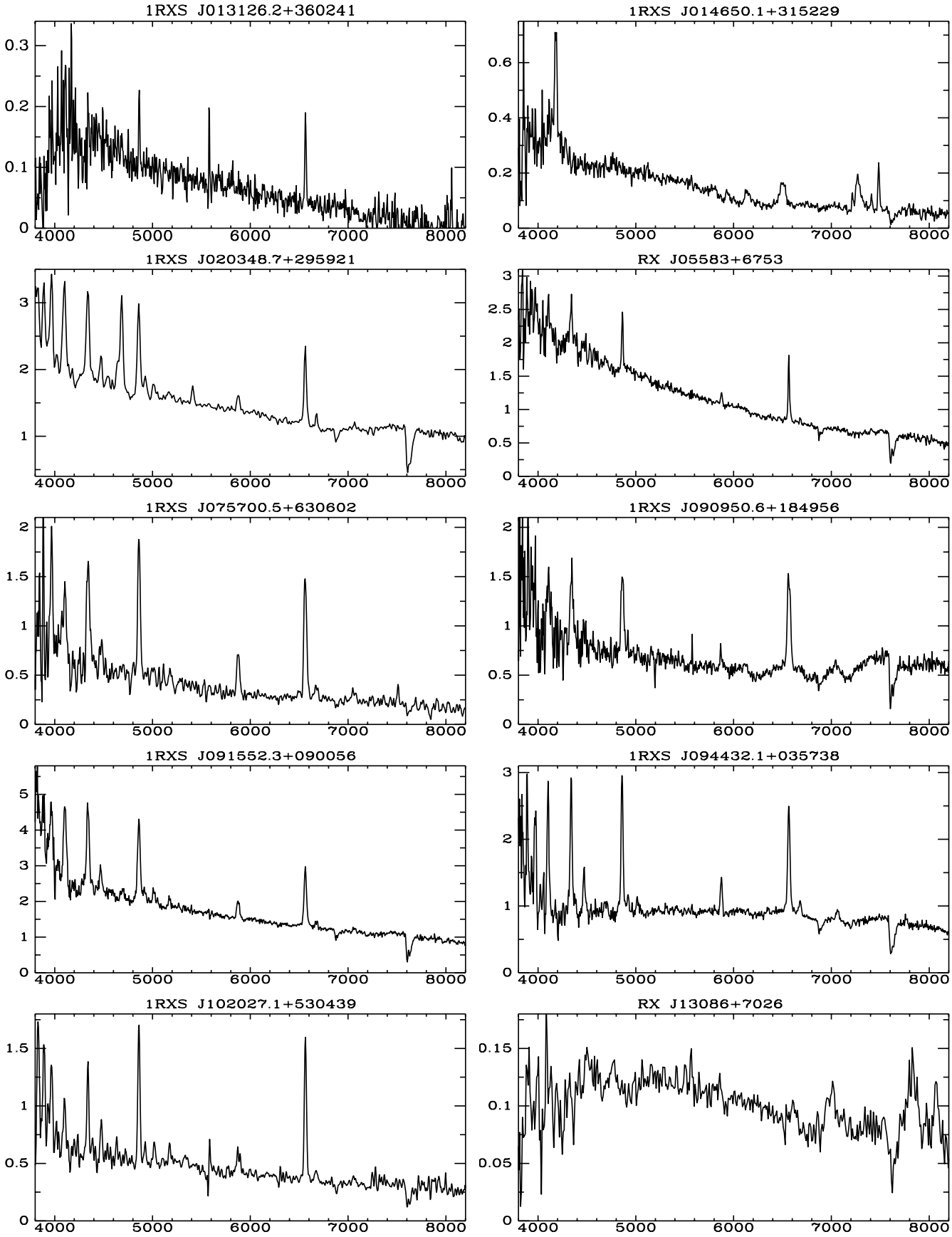

Fig. 1. Optical spectra of the counterparts to the X-ray sources. f_λ in units of 10^{-15} erg cm^{-2} s^{-1} Å^{-1} is plotted against wavelength in Å

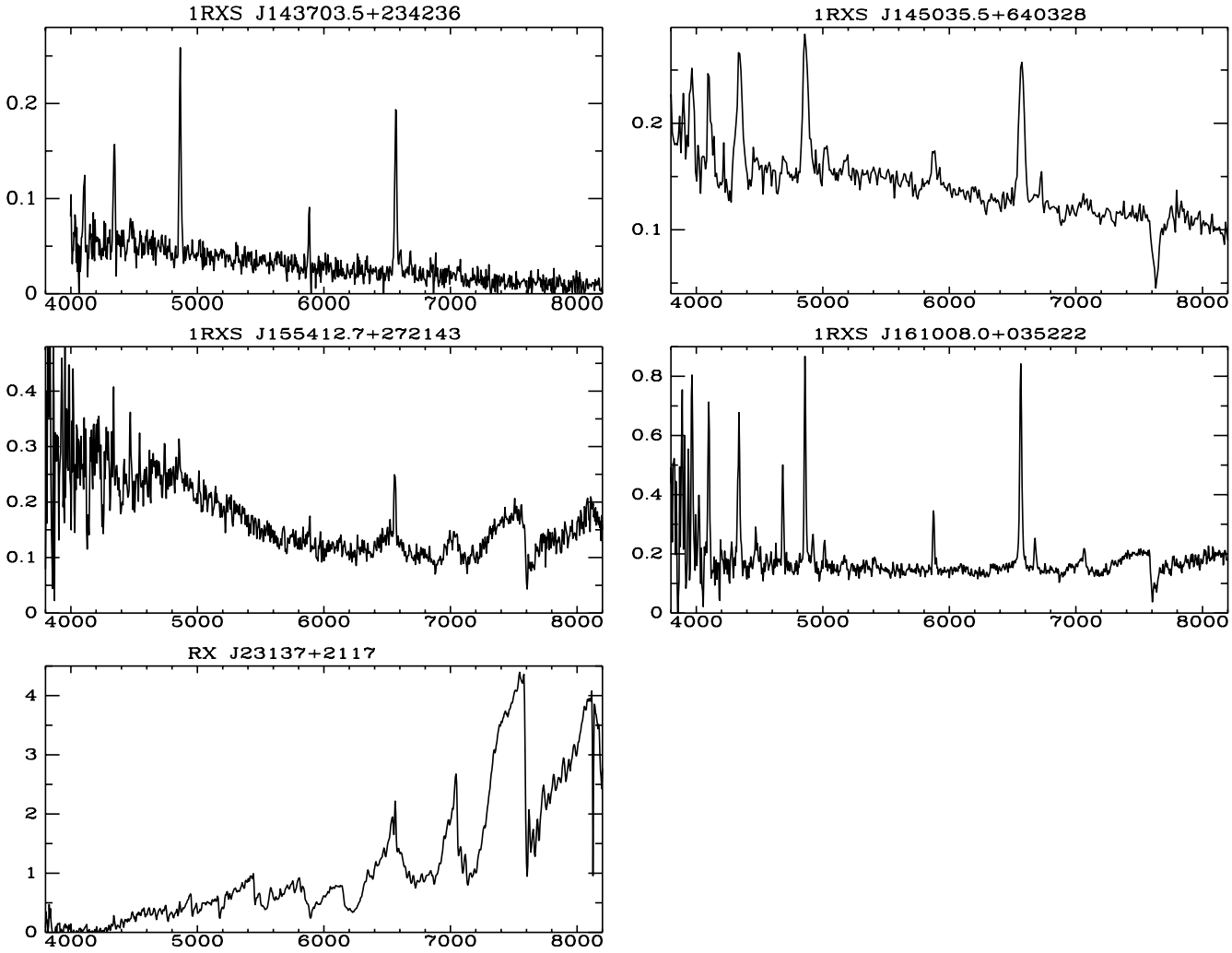

Fig. 1. (continued)

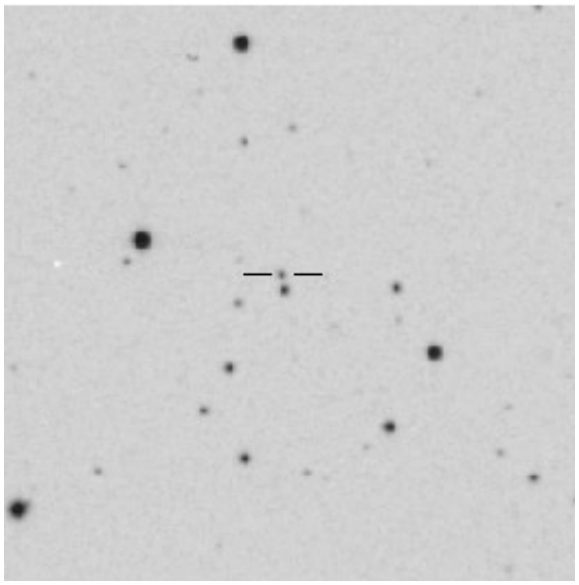

Fig. 2. Finding chart ($5' \times 5'$) for 1RXS J013126.2+360241 obtained from a POSS plate.

ered as H_γ emission line in the objective prism spectrum. The brightness variations implied by Table 1 are probably due to calibration uncertainties.

4. Conclusions

The discovery of new CVs combining X-ray data from the RASS and optical data from the HQS turns out to be very efficient. More than 80% of the candidates could be confirmed spectroscopically as genuine cataclysmic variables. The presence of two QSOs (13%) among the candidates indicate that a number of additional cataclysmic variables might hide among the RASS sources classified as AGN. The case of 1RXS 143703.5+234236, which was recognized as CV by Bade et al. (1998) only because it was in a bright state during one of the epochs covered by an objective prism plate, indicates that further CVs with faint optical magnitudes during quiescent state will be present among the ≈20% RASS sources, for which no plausible candidate has been found on the objective prism plates.

Acknowledgements. This work was partially supported by the Chinese National Natural Science Foundation.

References

Bade N., Engels D., Voges W., et al., 1998, A&AS 127, 145
Billington I., Marsh T.R., Dhillon V.S., 1996, MNRAS 278, 673
Dobrzycka D., Dobrzycki A., Engels D., Hagen H.-J., 1998, AJ 115, 1634
Fiedler H., Barwig H., Mantel K.H., 1997, A&A 327, 173
Gänsicke B.T., Fried R.E., Hagen H.-J., et al., 2000, A&A 356, 79
Hagen H.J., Groote D., Engels D., Reimers D., 1995, A&AS 111, 195
Monet D., Bird A., Canzian B., et al., 1999, USNO-A2.0, U.S. Naval Observatory, Washington
Nogami D., Engels D., Gänsicke B.T., et al., 2000, A&A, submitted
Reimers D., Hagen H.-J., Hopp U., 1999, A&A 343,157
Reimers D., Hagen H.-J., 2000, A&A submitted
Schwarz R., Schwope A.D., Beuermann K., Burwitz V., et al., 1998, A&A 338, 465
Schwope A.D., Hasinger G., Lehmann I., et al., 2000, Astron. Nachr. 321, 1
Thomas H.C., Beuermann K., Reinsch K., et al., 1998, A&A 335, 467
Tovmassian G.H., Greiner J., Kroll P., et al., 1998, A&A 335, 227
Voges W., 1992, In: Proceedings on European International Space Year Meeting ESA ISY-3,9
Voges W., Aschenbach B., Boller Th., et al., 1999, A&A 349, 389