Binary pulsars observed with MAXI

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Abstract

X-ray binary pulsars observed with MAXI were presented. The light curves and the spectra of 13 persistent sources and 7 Be binaries were shown in the conference. A0535+26 exhibited a giant outburst followed by two smaller "giant" outbursts. Their period was 115 d which is longer than 110 d orbital period. Precursors were also observed. The giant outburst from GX 304-1 in August 2010 was followed-up by Suzaku and cyclotron structure was discovered at 54 keV .

Key words: pulsars — MAXI – GSC — Be binary

1. Outburst light curves

Since the start of the regular operation on 2009 August 15 MAXI/GSC observed activities of many X-ray binary pulsars (Mihara et al. 2011, Sugizaki et al. 2011). In the conference, the light curves and the spectra of 13 persistent sources and 7 Be binaries were presented. Till the end of 2011 the number has increased to 35 outbursts from 13 Be binary pulsars. Figure 1 shows those outbursts. Eight of them has a width (FWHM) of outbursts of $\sim 4-6$ days. Exceptions in the long side are 2S 1417-624 (26 days) and XTE J1946+274 ($\sim$ 12 days), and those in the short side are 4U 0115+634 (2.5 days) and V 0332+53 (3 days). The orbital period does not always affect the outburst width.

The MAXI/GSC spectra of 20 binary pulsars were fitted with a power-law model (or partial covering model) and summarized in Table 1.

2. Giant outburst and normal outburst of A0535+26

A0535+26 exhibited a giant outburst followed by two smaller "giant" outbursts. Their period was 115 d which is longer than 110 d orbital period. Precursors were observed prior to the giant outbursts with the same 115 d period. The peak intensity of the first three succeeding outbursts decayed exponentially with e-folding time scale of 89.0 days (Nakajima et al. 2012).

3. Suzaku follow-up observations of GX 304-1

GX 304-1 had a giant outburst in August 2010. We conducted Suzaku TOO observation and found a cyclotron structure at 54 keV (Yamamoto et al. 2011).

Table 1. Spectral parameters of the binary pulsars with MAXI/GSC observed by November 2010.

Persistent stable	F_x	$N_{\rm H}$	Γ	Fe
3A1145-616	20	6, 36	2.0	-
4U1538-52	20	4	1.1	-
4U1626-67	30	0	1.0	-
X Per	70	5	2.0	-
Persis. variable	F_x max			
Cen X-3	300	4	1.2	o
GX 1+4	80	11	1.4	o
OAO1657-41	80	4	1.4	o
Vela-1	400	8	0.2	o
Orbital / super orbital				
EXO2030+375	100	4	0.7	-
GX 301-2	150	6, 107	0.25	o*
Her X-1	100	2	0.86	o
LMC X-4	25	0	1.1	-
SMC X-1	80	4	1.4	-
Be outbursts				
A0535+262	2000	3, 21	1.2	-
GX 304-1	800	4, 25	1.8	-
GRO J1008-57	120	7	1.6	-
LS V +44 17	150	7	1.9	-
V0332+53	60	1.4	0.6	-
2S1417+624	70	18	0.1	-
XTE J1946+274	100	5	1.2	-

F_x is in mCrab in 2-10 keV. $N_{\rm H}$ is in 10^{22} cm^{-2}.
Γ is the photon index.
* : EW$\sim$300 eV
Two $N_{\rm H}$ numbers indicate partial covering model.

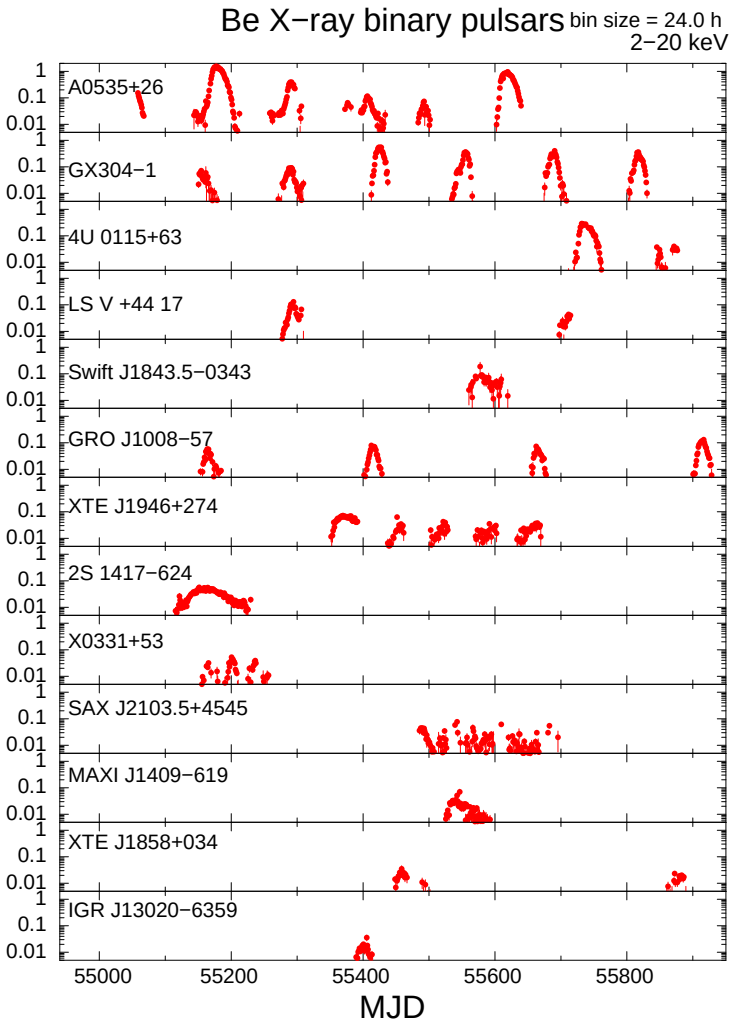

Fig. 1. The light curves of 13 Be X-ray binaries, whose outbursts were observed with MAXI/GSC by 2011. Fluxes are in crab unit.

4. Super-orbital modulation and flares of LMC X-4

The super-orbital period of LMC X-4 was observed clearly with MAXI. The period was 30.27 days (Morii et al. in prep.). It showed flaring activity reaching $\sim 10 L_{\rm edd}$ lasting for about 1000 s twice in the first year of MAXI. Each high-luminosity episode lasted for about 1 day. The spectrum in the flare is flat as $\Gamma = 1.2$ compared to the normal value of $\Gamma \sim 2$ in LMC X-4. Those flaring behaviours are common in the OB high mass X-ray binaries, such as LMC X-4 and Cen X-3.

5. Irregular outburst in apastron of GX 301-2

The persistent Be binary GX 301-2 normally has a flux increase at periastron. However, it sometimes shows outburst in apastron which accompanies a rapid spin-up, which was first reported with BATSE observation in 1991 and 1993 (Koh et al. 1997). The apastron outburst of GX 301-2 in June 2010 (Finger et al. 2010) was also detected with MAXI.

6. RXTE follow-up observations of LS V +44 17

An outburst from LS V +44 17 was found by MAXI in April 2010. The follow-up observations with RXTE revealed a dip-like feature in a certain pulse phase. Detail analysis was reported by Usui et al. (2012).

References

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