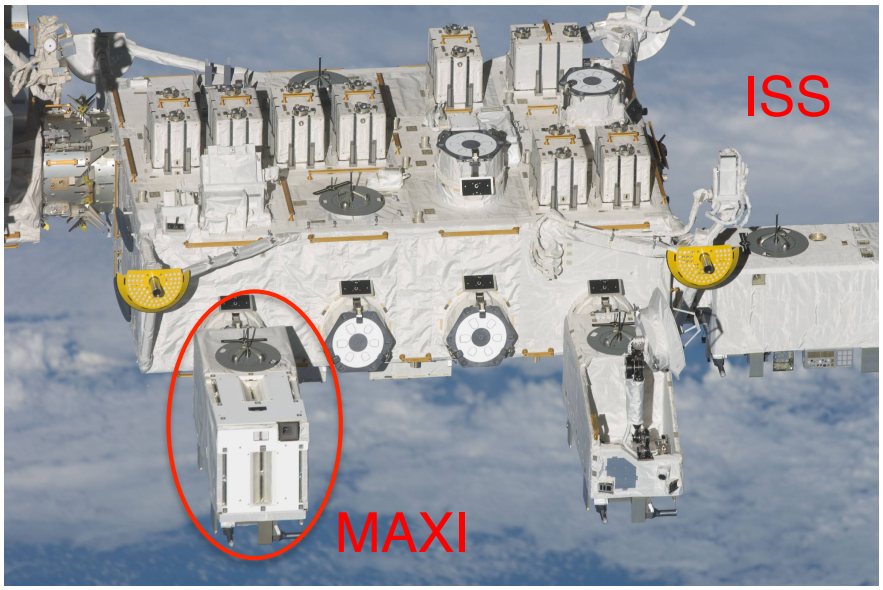
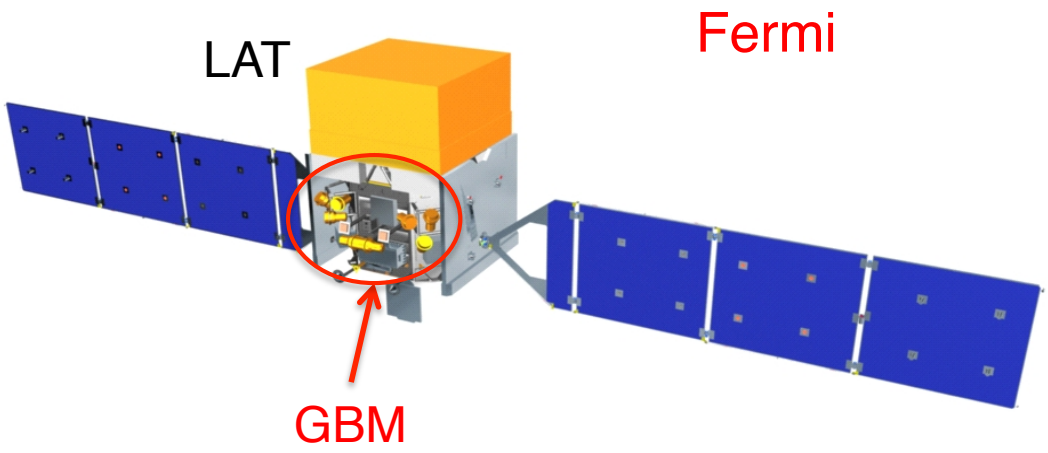


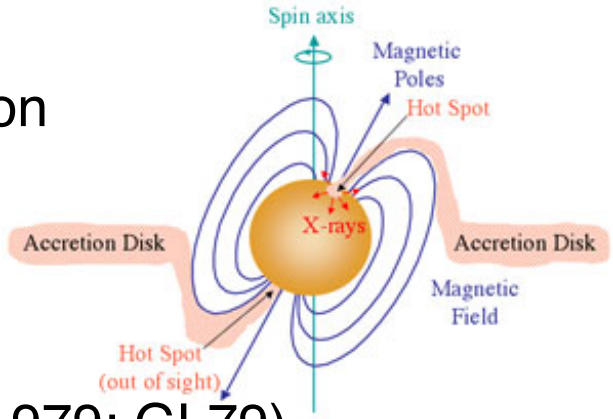


Study of luminosity and spin-up relation in X-ray binary pulsars with MAXI/GSC and Fermi/GBM.

Mutsumi Sugizaki, Tatehiro Mihara (RIKEN),
Motoki Nakajima (Nihon Univ.),
Kazutaka Yamaoka (Nagoya Univ.)

Spin-period change of Be/X-ray pulsar during outbursts

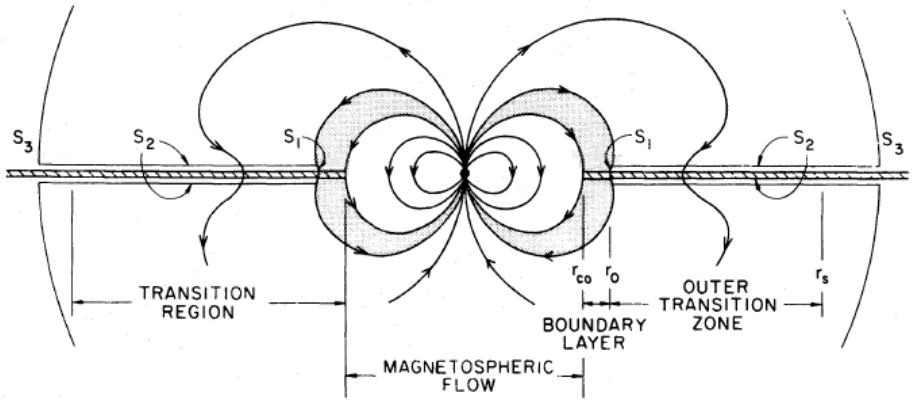
1. Pulsar passes through Be disk around periastron
2. Mass-accretion increases … X-ray Outburst
3. Angular momentum transfers … Spin up

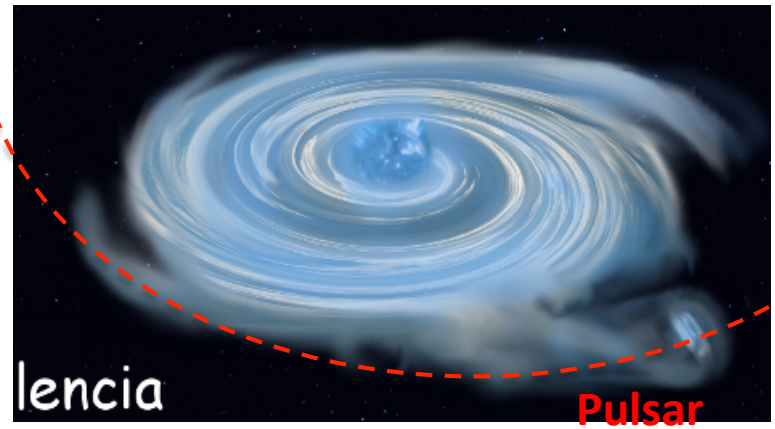


- Relation between L_X and Pdot (Ghosh & Lamb 1979; GL79)

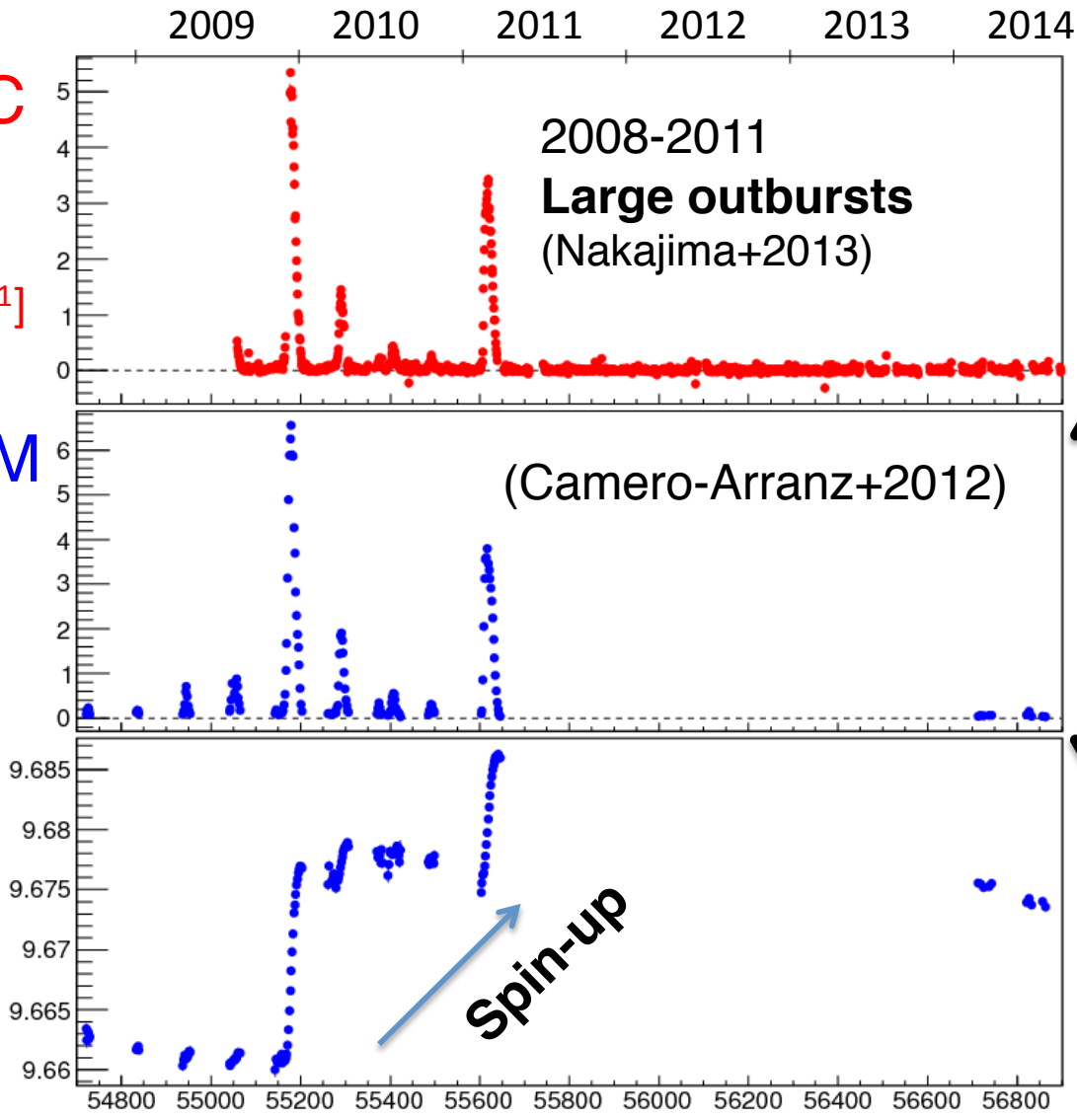
$$-\dot{P} = 5.0 \times 10^{-5} \mu_{30}^{2/7} n(\omega_s) S_1(M) (P L_{37}^{3/7})^2 \text{ s yr}^{-1}$$

- give us information on
  - ✓ NS physical parameters (mass *M*, radius *R*, magnetic field *B*)
  - ✓ Evolution of X-ray binaries





Data example of MAXI/GSC and Fermi/GBM: A 0535+26



MAXI / GSC
X-ray flux
2-20 keV flux
[Photons cm^{-2} s^{-1}]

Fermi / GBM
Pulsed flux
15-50 kev
[keV cm-2 s-1]

Pulse frequency
[mHz]

covers main X-ray emission band (2-20 keV)

Test with total flux and pulse *P*

Previous works:
Study of pulsed flux and *P* with BATSE (Bildsten+1997) or Fermi/GBM

(Fermi/GBM pulsar project)

Analysis

- Targets: Be X-ray pulsars which occurred large outbursts

	P_{pulse} [s]	P_{orb} [d]	$A_x \sin i$ [lts]	Ecc.	B [10^{12}G]	Dist. [kpc]
A 0535+26	103	111.10	267	0.47	4.3	2.4
GX 304-1	275	132.19	480	0.54	4.7	2.0
GRO J1008-57	93	249.48	530	0.68	6.6	5.8
KS 1947+300	18	40.42	137	0.034	1.1	10.0
2S 1417-624	17	42.18	188	0.44	-	11.0

- $\Delta P_{obs}(t)$: Observed *P* change (Fermi/GBM)

$$\Delta P_{GL}(t) = -\int 5.0 \times 10^{-5} \mu_{30}{}^{2/7} n(\omega_s) S_1(M) (P L_{37}{}^{3/7})^2 dt$$

Calculated from 2-20 keV flux (MAXI/GSC) and GL79 model
(R=10 km, M=1.4 M_{sun}, I=10^{45} g cm^2)

$$\Delta P_{obs}(t) = \alpha \Delta P_{GL}(t) - \beta t$$

Main Uncertainty: Bolometric luminosity correction for Lx

Assume: MAXI/GSC 1-day average flux smears the emission beaming effect.

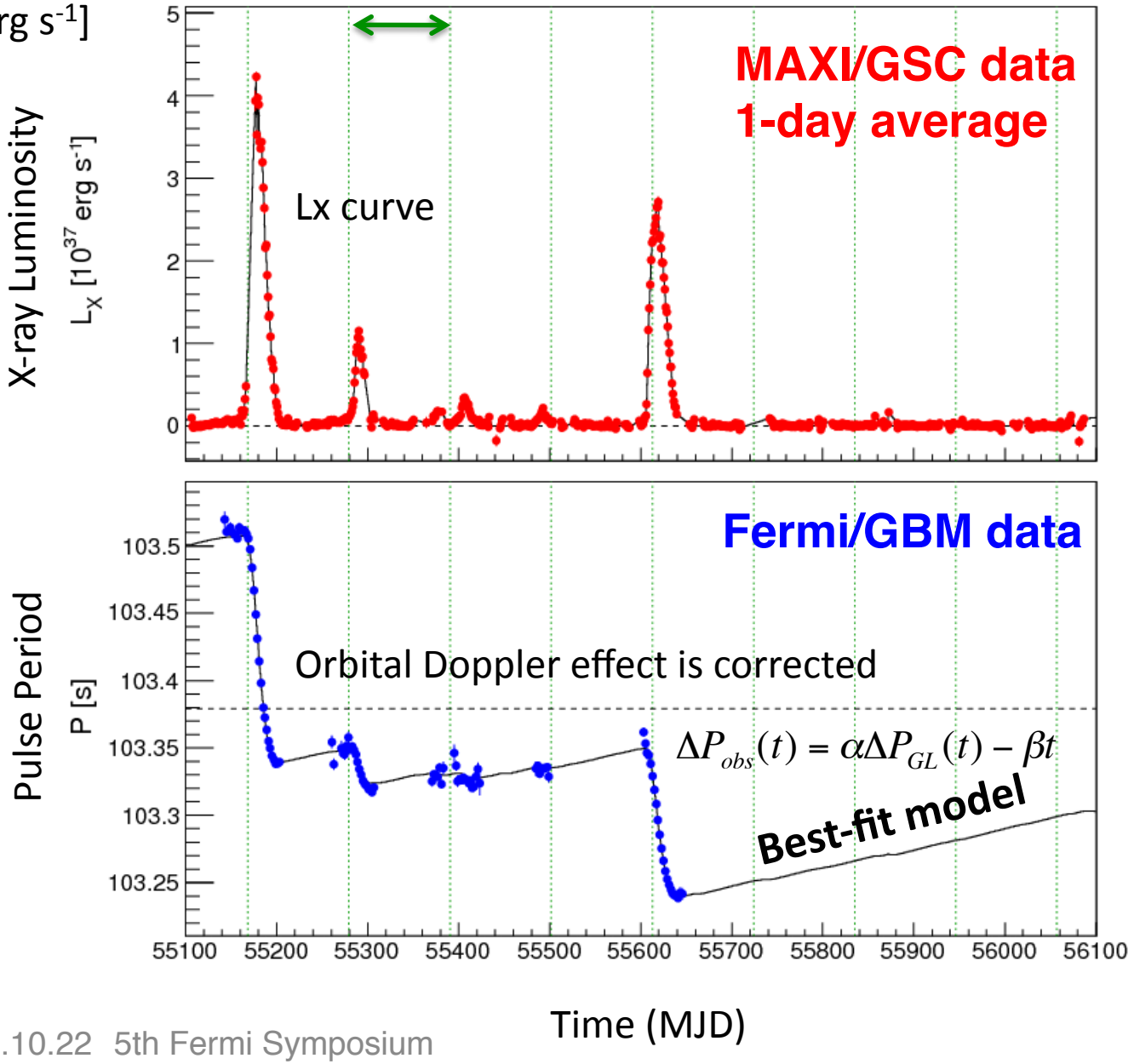
Typical cutoff-powerlaw spectrum.

Distance estimate is correct.

1st sample: A 0535+26

L_{peak}=5x10^{37} [erg s^{-1}]

Periastron passage (Porbit = 111.1 days)



Binary elements
P_{orbit} = 111.1 d
P_{spin} = 103 s
$a_x \sin i$ = 267 lt-s
e = 0.47

d = 2.4 kpc
B = 4.3 x 10^{12} G

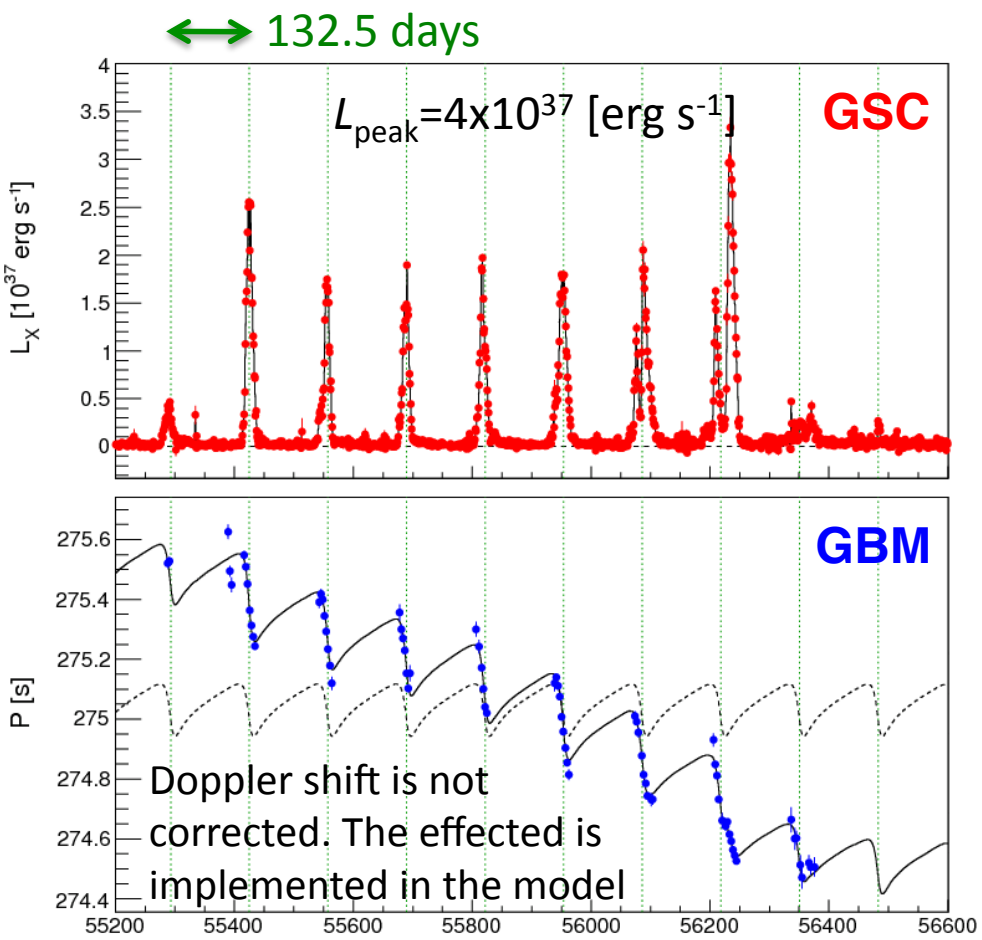
From model fit,

$$\alpha = 1.3 \approx \frac{\Delta P_{obs}}{\Delta P_{GL}}$$

$$\beta = 3 \times 10^{-4} \text{ s d}^{-1}$$

Reasonably good!

GX 304-1

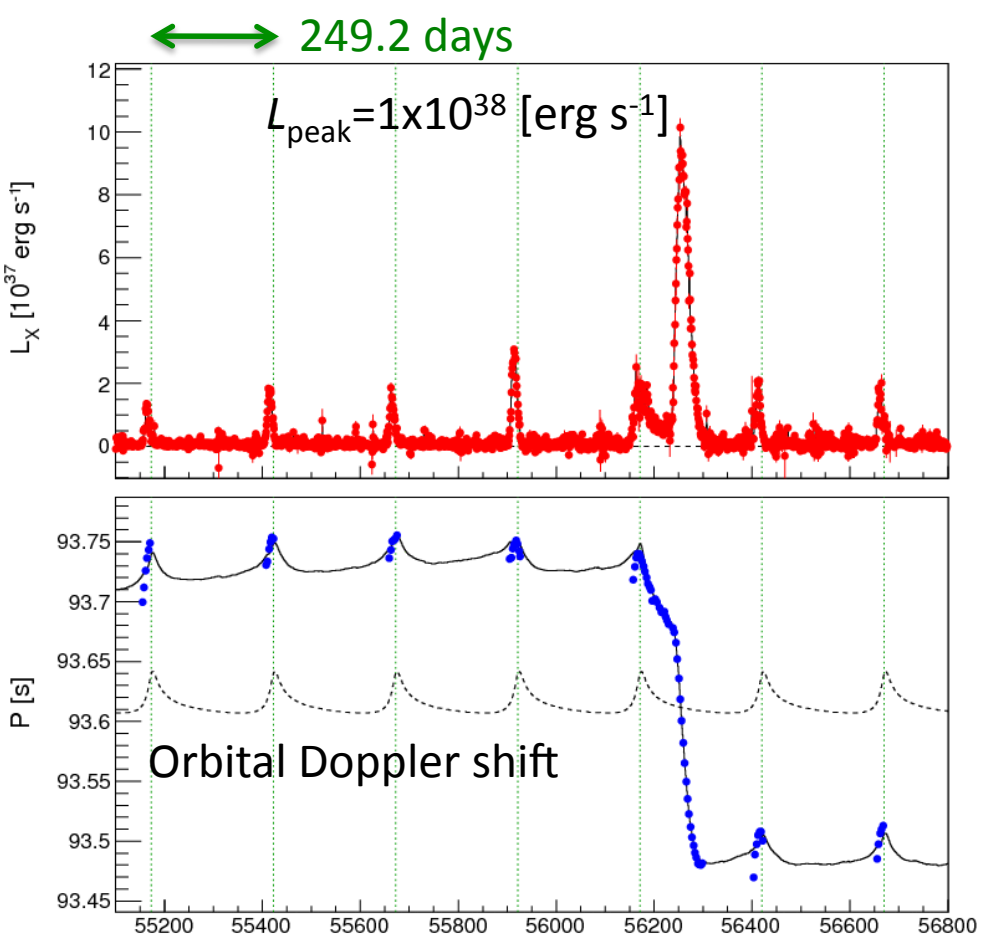


P_{orbit} = 132.19 d
P_{spin} = 275 s
$a_x \sin i$ = 483 lt-s
e = 0.54

d = 2. kpc
B = 4.3 x 10^{12} G

$\alpha = 0.28$

GRO J1008-57



P_{orbit} = 249.48 d
P_{spin} = 93 s
$a_x \sin i$ = 530 lt-s
e = 0.68

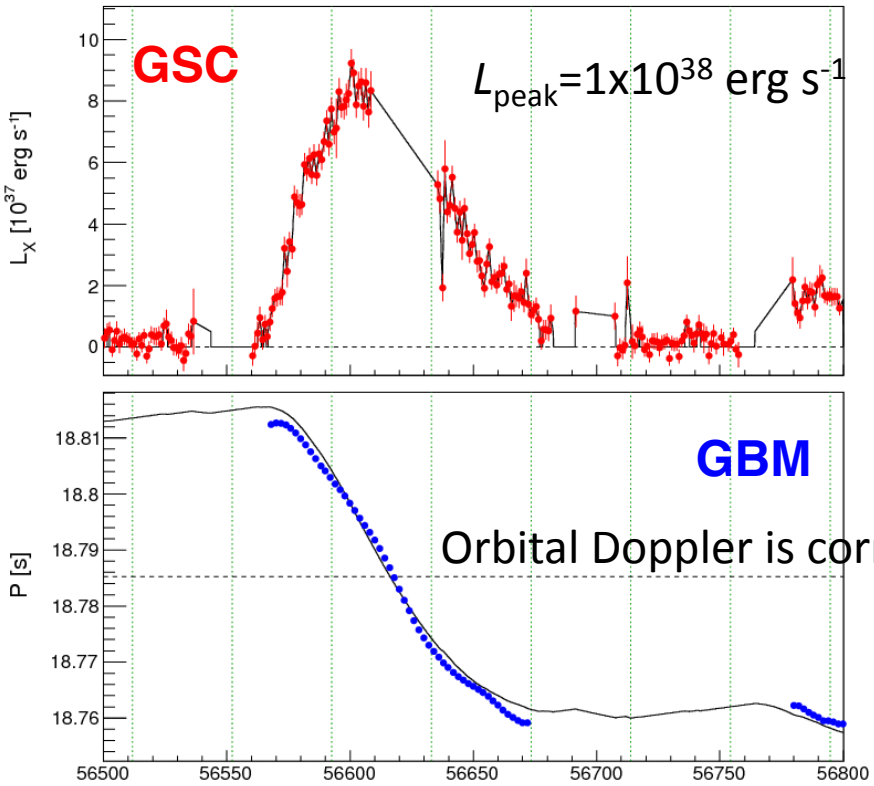
d = 5.8 kpc
B = 6.6 x 10^{12} G

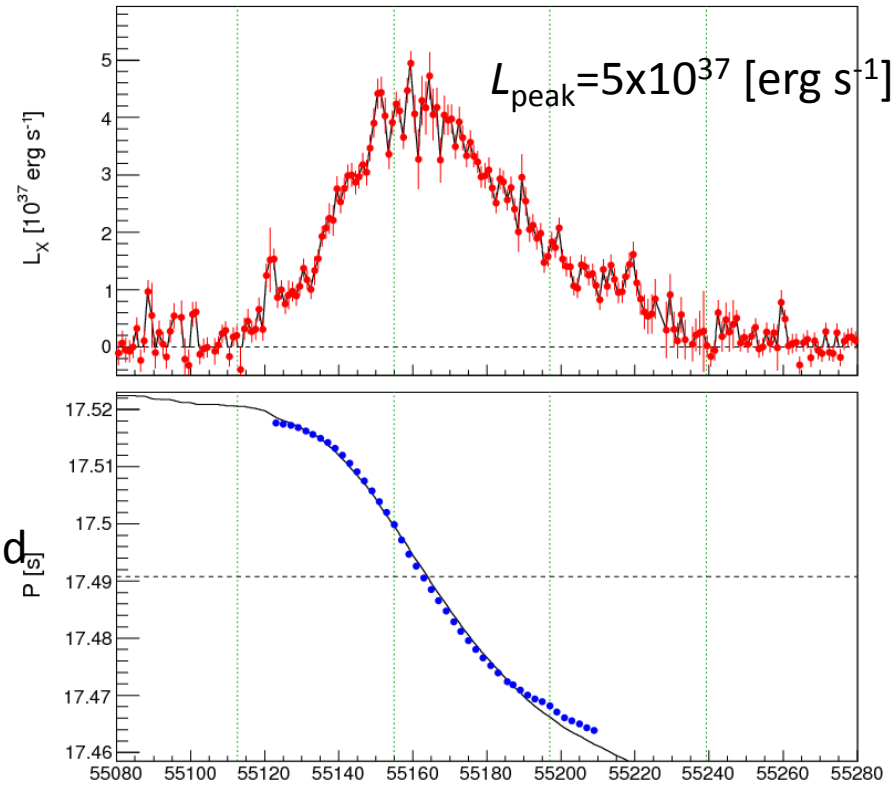
$\alpha = 0.49$

KS 1947+300

2S 1417-624

↔ 40 days Outbursts lasted over the orbital period. ↔ 42 days





P_{orbit} = 40.415 d
P_{spin} = 18 s
$a_x \sin i$ = 137.4
e = 0.0340

d = 10 kpc
B = 1.1 x 10^{12} G

$\alpha = 3.2$

P_{orbit} = 42.175 d
P_{spin} = 17 s
$a_x \sin i$ = 188
e = 0.44

d = 11 kpc
B = Unknown
Assume 2 x 10^{12} G

$\alpha = 6.8$

Summary of Current Results

	P_{pulse} [s]	P_{orb} [d]	$A_x \sin i$ [lts]	Ecc.	B [10^{12}G]	Dist. [kpc]	α ($\Delta P_{obs} / \Delta P_{GL}$)
A 0535+26	103	111.10	267	0.47	4.3	2.4	1.3
GX 304-1	275	132.19	480	0.54	4.7	2.0	0.28
GRO J1008-57	93	249.48	530	0.68	6.6	5.8	0.49
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2S 1417-624	17	42.18	188	0.44	-	11.0	6.8

- The values of α ($\approx \Delta P_{obs} / \Delta P_{GL}$) are almost within an order of magnitude.
- They seem to be classified into subgroups.

  (A). $\alpha < 1$ and (B). $\alpha > 1$
- What causes the subgroup classification ?
  - Magnetic field. Pulse profile ?
  - Outburst duration – accretion mode ?
  - Orbital parameters, P_{orb} and eccentricity, may relate with the problem.
- We need more sample! Further analysis is undergoing.