INTEGRAL view of LS I +61 303 in orbital/superorbital phase space

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Outline

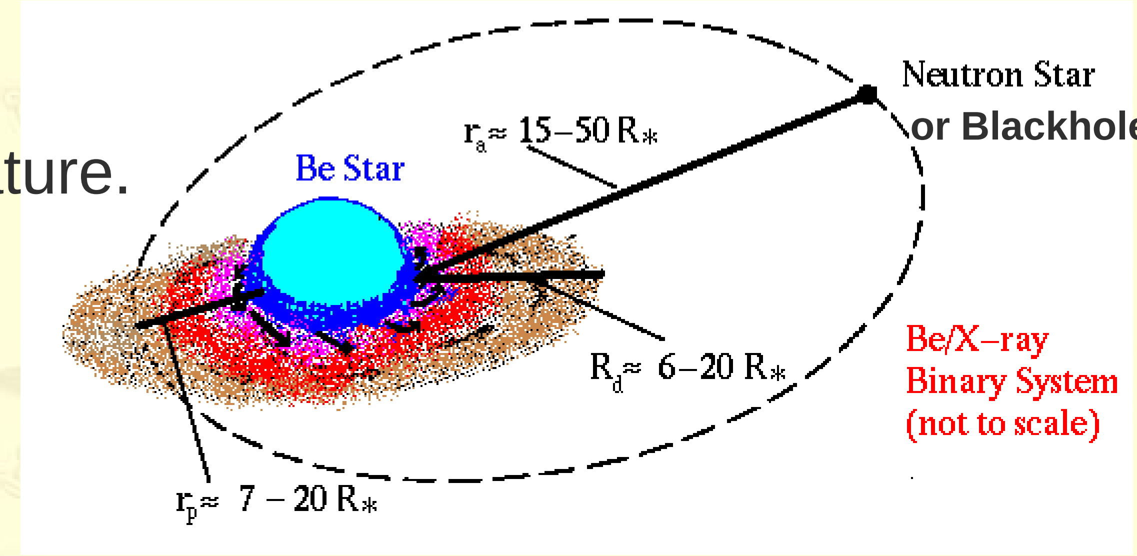
- 1. Introduction of LSI +61◦303
- 2. Spectral analysis in orbital/superorbital phase space
- 3. Hints of superorbital variability in the hard x-rays
- 4. Conclusions

Introduction

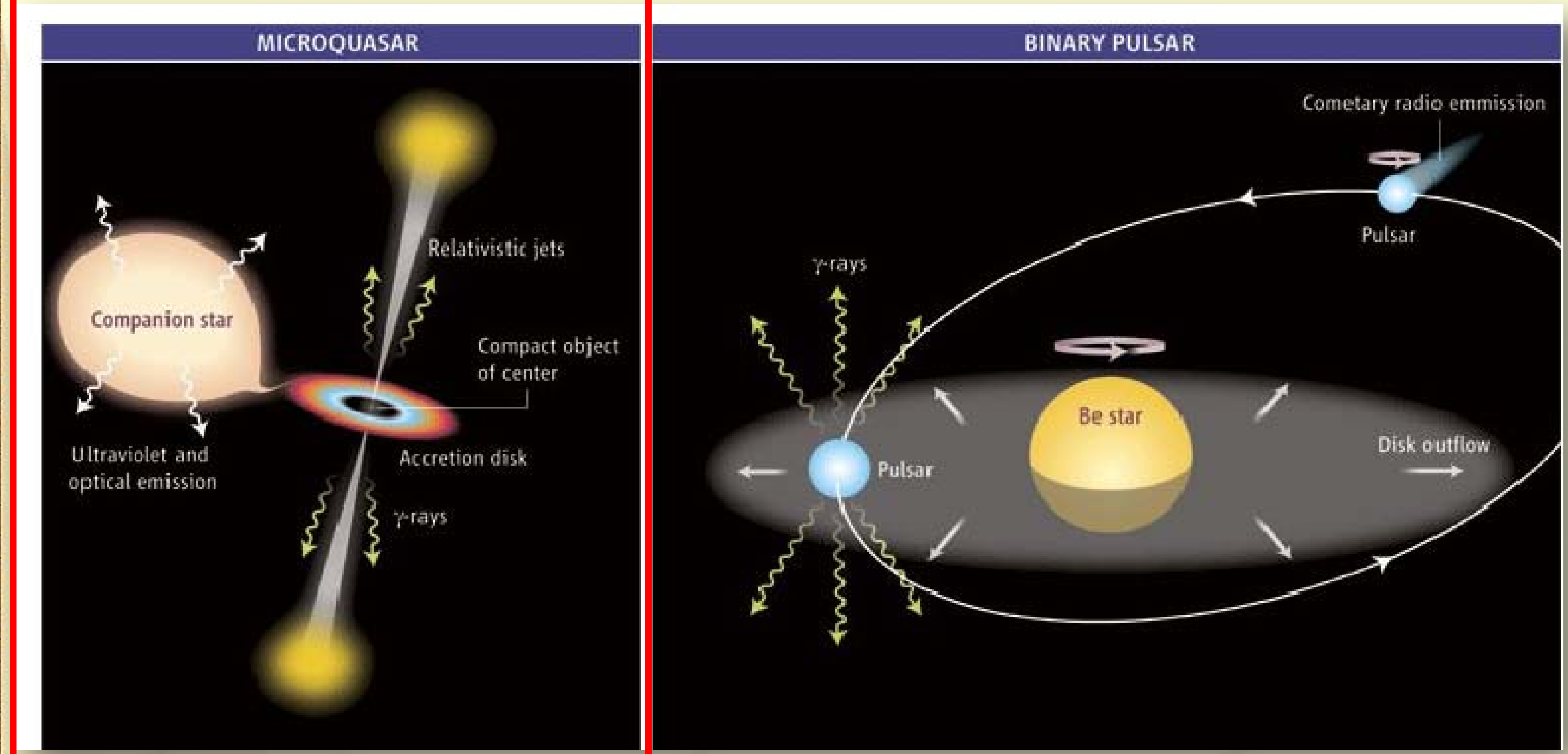
LSI +61 303 is a Be X-ray / gamma-ray binary,
2 ± 1 kpc,
Orbit period: 26.496 ± 0.0028 days.
Superorbital period : 1667 ± 8 days

Companion: B0 Ve star
Mass: $\sim 12.5 \pm 2.5\ M_\odot$
Radius: $\sim 10\ R_\odot$

Compact object:
1-4 $M_\odot$ with unknown nature.



- LSI +61 303 is among the elite gamma-ray binary group



Proposed scenarios for gamma-ray binary

Spectral analysis in orbital/superorbital phase space

- In the hypothesis of LSI + 61 303 being a microqusar, Zimmermann & Massi (2012) expected:

a steady jet (radio index $\alpha>0$) in the Hard X-ray state, $1.5 < \Gamma < 1.8$ and a cutoff at high energies.

a transient jet (radio index $\alpha<0$) in the Steep Powerlaw state (SPL),
$\Gamma>2.4$.

radio index variations is explained in terms of a microquasar's changes of state.

- No high energy cutoff is ever discover in LSI +61 303

- The spectrum of LSI +61 303 is always well fitted by a power law with Γ < 2.4,

  with only one case , Γ = 3.6 (+1.6/-1.1), but the error bars are large. (Chernyakova et al. 2006)

Table 2. Orbitally separated spectra from ISGRI/IBIS observations (the results of our analysis are marked with a star) and a comparison with the previous work by Chernyakova et al. (2006), quoted in the three last columns.

Orbital phase	$\Gamma^\star$ (1σ)	Flux* (20–60 keV) (10^{-11} erg cm^{-2} s^{-1})	Effective exposure* (ks)	Γ (1σ)	Flux (20–60 keV) (10^{-11} erg cm^{-2} s^{-1})	Effective exposure (ks)
0.4–0.6	1.9 ± 0.2	2.84 ± 0.54	127	1.7 ± 0.4	3.8 ± 0.6	50
0.6–0.8	1.5 ± 0.3	2.09 ± 0.52	144	$3.6^{+1.6}_{-1.1}$	3.0 ± 1.0	23
0.8–0.4	$1.4^{+0.4}_{-0.3}$	1.07 ± 0.36	307	1.4 ± 0.3	2.4 ± 0.3	200
Whole orbit	1.7 ± 0.2	1.74 ± 0.26	578	1.6 ± 0.2	2.5 ± 0.3	273

Zhang et al. 2010

With exposure time doubled (Li et al. 2014):

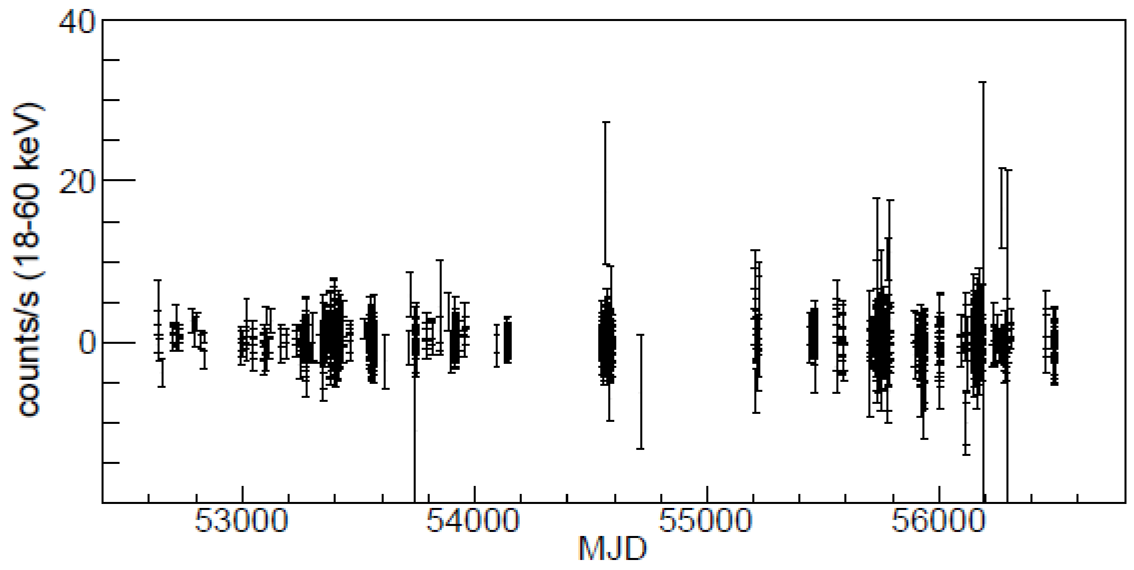
Orbital Phase	X-Ray Photon Index (Γ)	Flux (18–60 keV) (10^{-11} erg cm^{-2} s^{-1})	Reduced χ^2(dof)	Effective Exposure (ks)
0.0–0.4	$1.90^{+0.47}_{-0.40}$	1.63 ± 0.29	0.256 (4)	219.3
0.4–0.5	$1.60^{+0.22}_{-0.21}$	2.84 ± 0.30	0.763 (5)	162.3
0.5–0.6	$1.54^{+0.28}_{-0.25}$	2.84 ± 0.39	0.358 (8)	118.2
0.6–0.7	$1.44^{+0.32}_{-0.30}$	2.24 ± 0.35	0.424 (4)	154.2
0.7–1.0	$0.70^{+0.33}_{-0.34}$	$0.98^{+0.28}_{-0.27}$	0.26 (3)	273.7

- The absence of states transitions could because the data are folded over too long time (Zimmermann & Massi (2012))

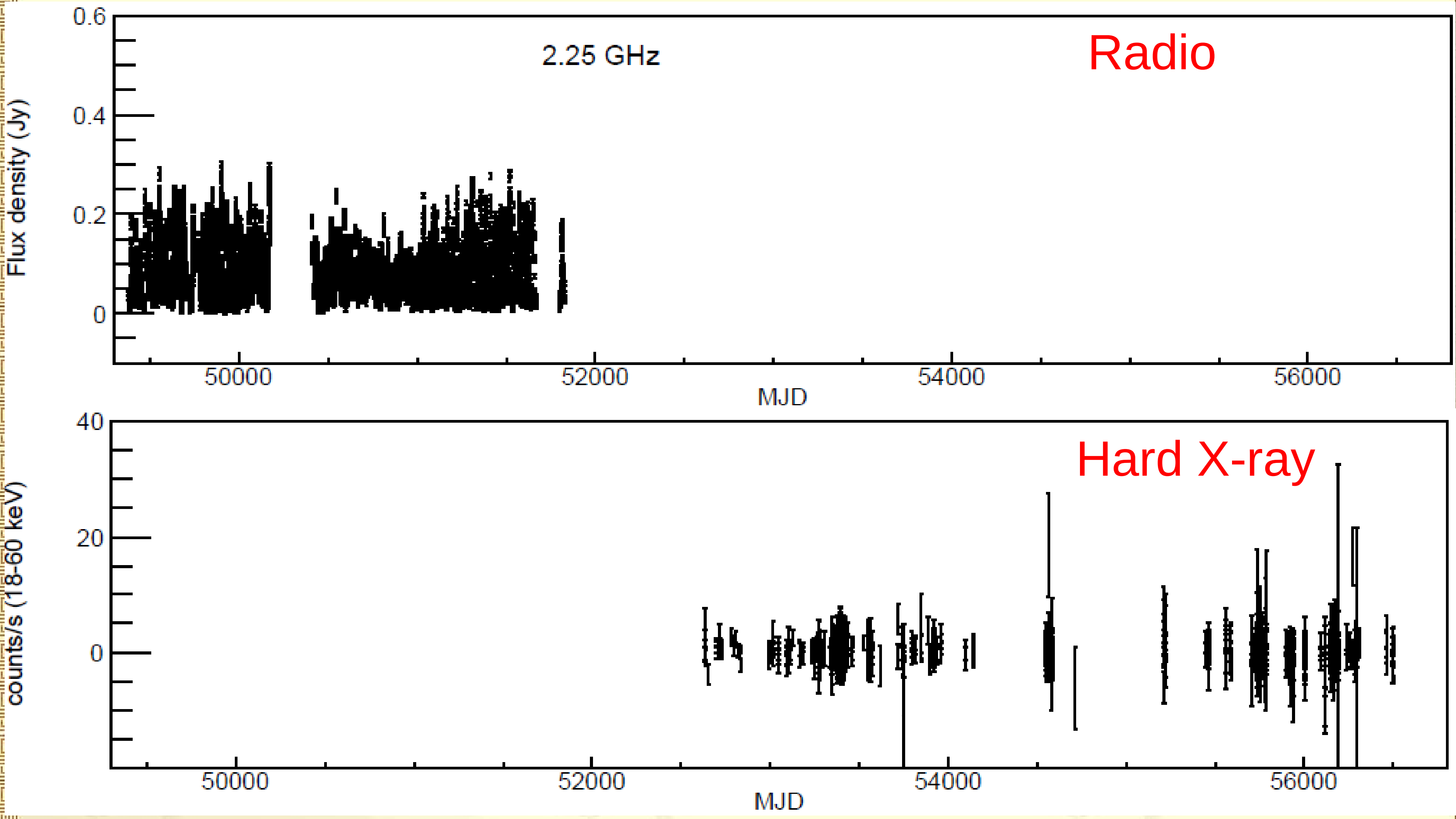
Radio X-ray

α>0 ➡ 1.5 < Γ < 1.8 + a cutoff

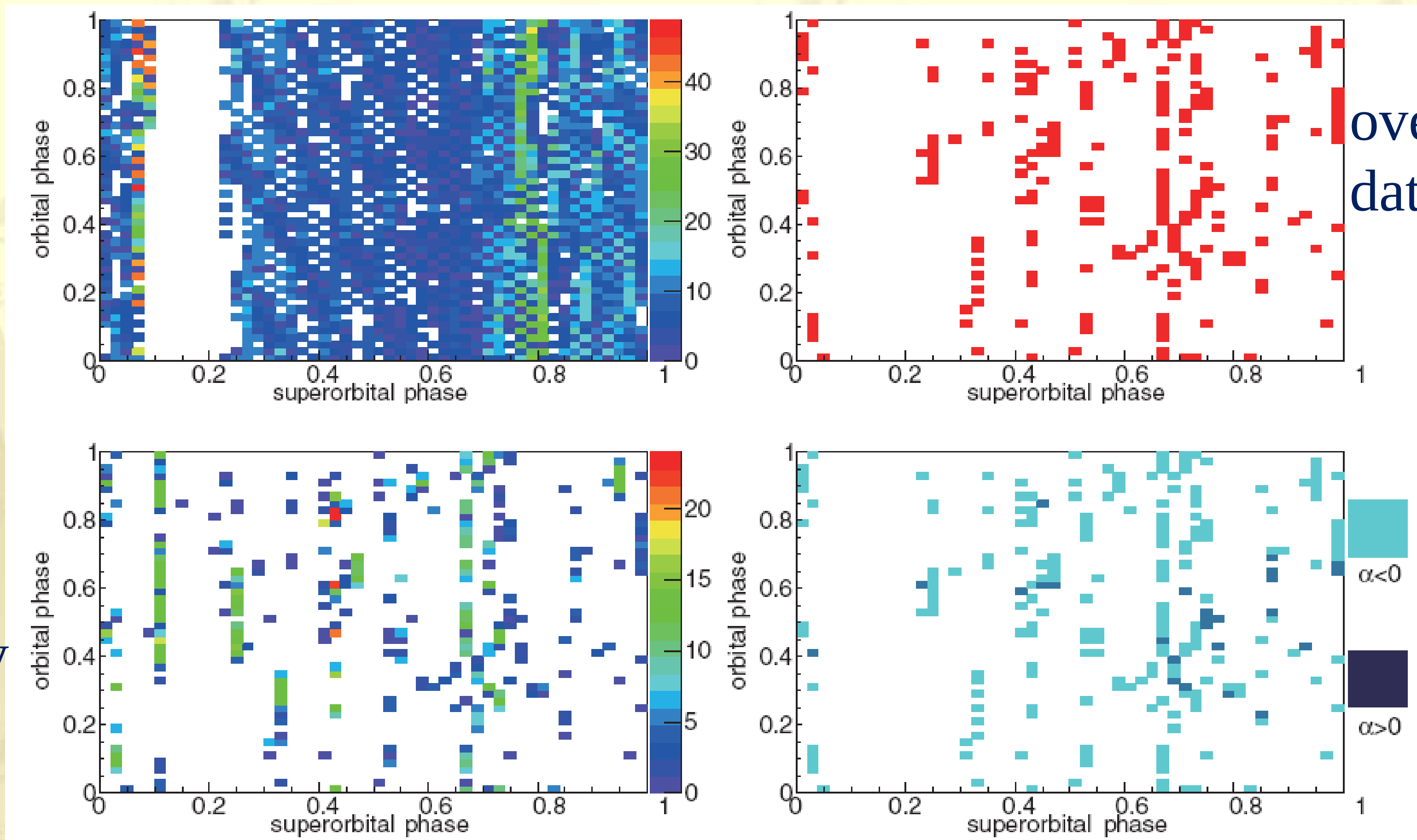
α<0 ➡ Γ>2.4



- To test this, simultaneous radio and hard X-ray observations are the best choice, but…



- To solve the difficulties , we introduce the orbital/superorbital phase space



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Expected

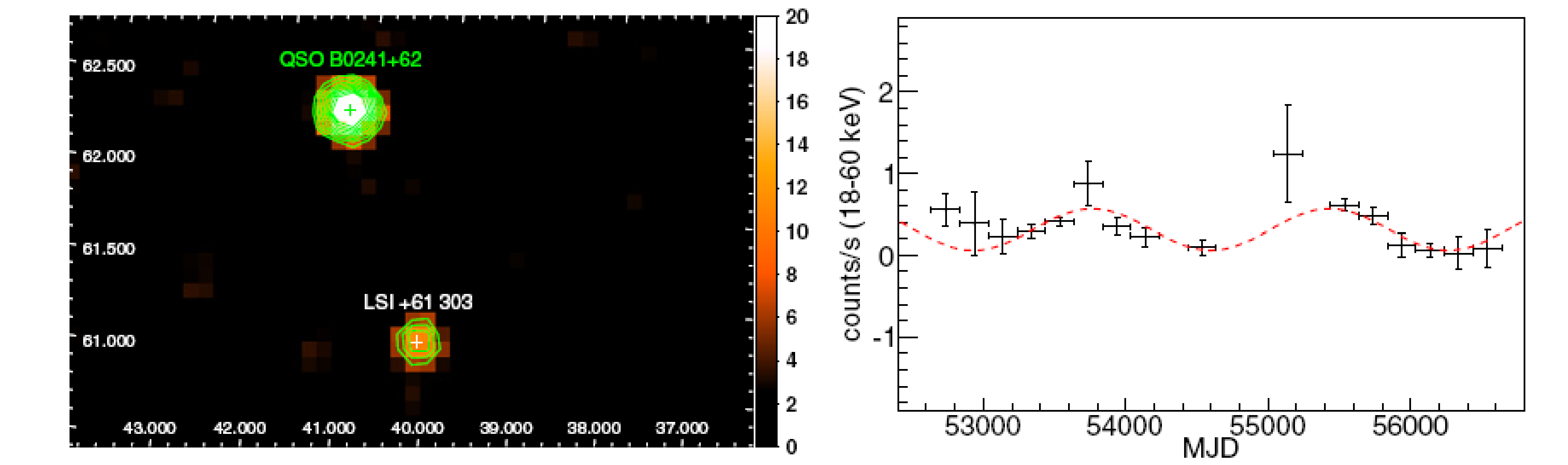
Radio Index	X-ray Photon Index (Γ)
$\alpha < 0$	$\Gamma > 2.4$
$\alpha > 0$	$1.5 < \Gamma < 1.8$ + a cutoff

Observed

Radio Index	X-Ray Photon Index (Γ)
$\alpha < 0$	$1.49^{+0.21}_{-0.19}$
$\alpha > 0$	$2.59^{+1.01}_{-0.83}$

Li et al. 2014

Hints of superorbital variability in the hard x-rays

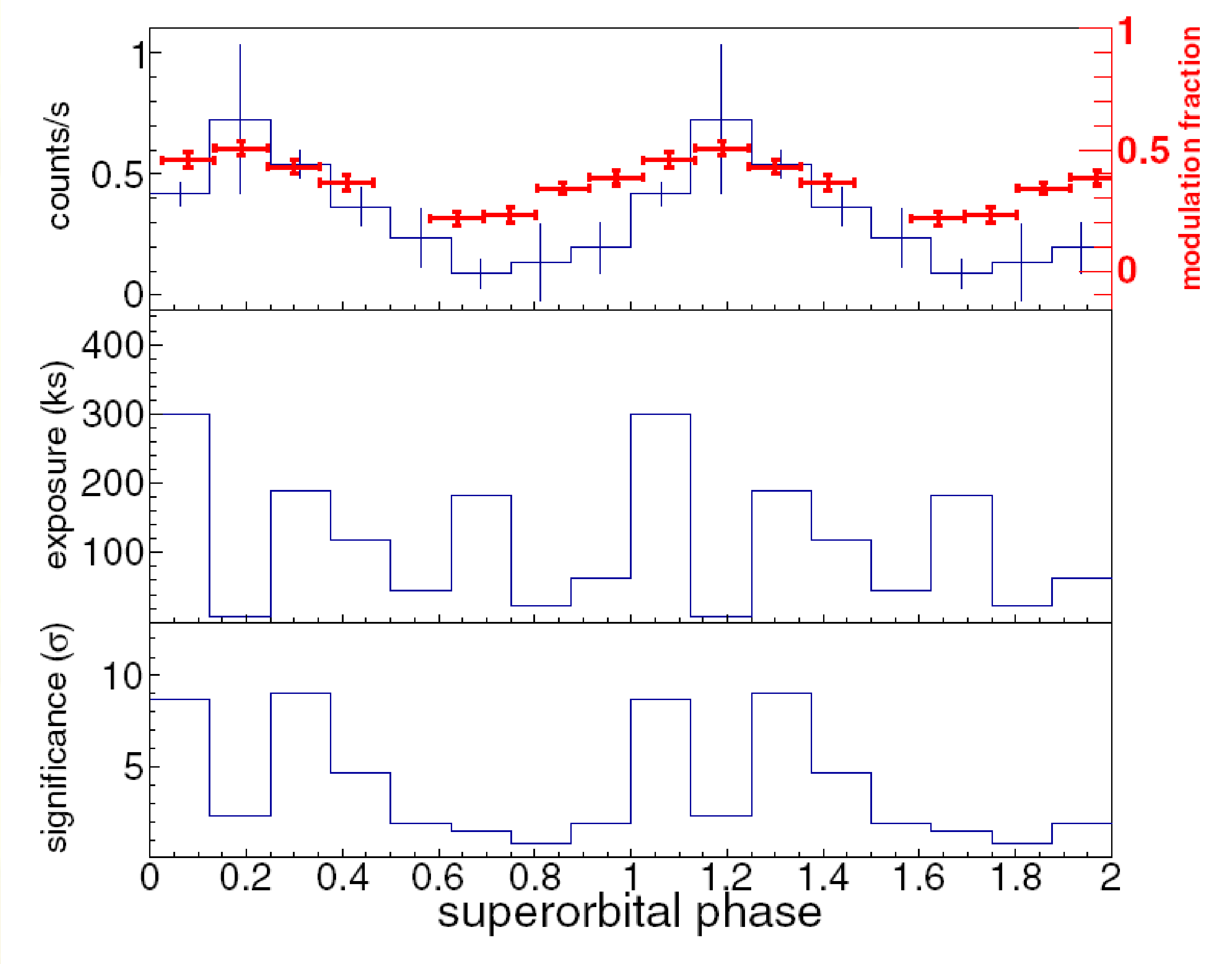


- LSI + 61 303 is detected at 11 σ in 18-60keV.

- The 200 days binned light curve shows a variability at 4.3 σ significance.

 (χ^2 : 50.92/16 constant fitting

 13.42/14 1667 days sinusoidal function)



Soft X-ray, 3-30 keV, RXTE

- Super orbital light curve, exposure and significance

- a constant fit to the light curve yields a reduced χ^2 of 36.8/7, indicating variability at the 4.6σ level.

Conclusion

- We found the absence of an X-ray spectrum softening during periods of negative radio index.

  This does not favor a simple interpretation of the radio index variations in terms of a microquasar's changes of state.

- 2. We show hints that the superorbital variability of LS I +61◦303 in hard X-rays, which is in line with the superorbital variability observed in other frequencies.

Thank you!