

Burst-disk interactions of long thermonuclear X-ray bursts

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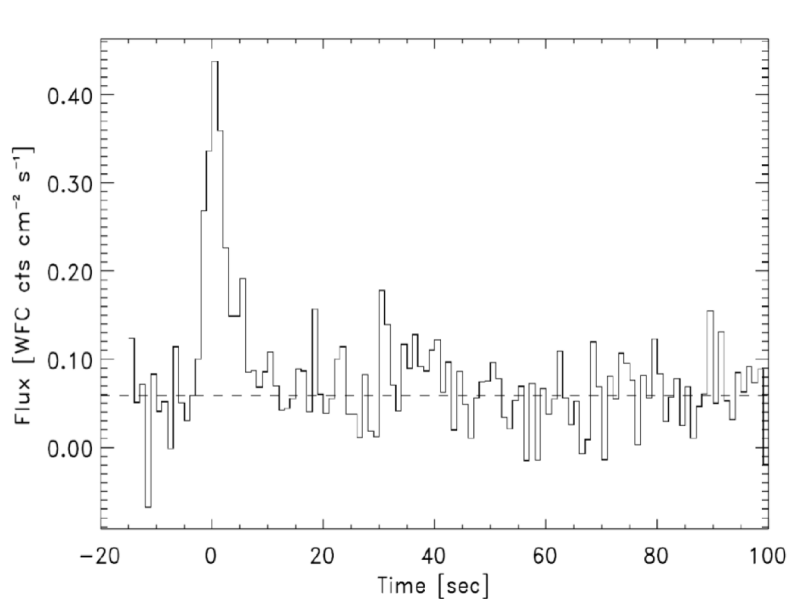
Outline

- **Neutron star mass and radius measurements**
- **Thermonuclear X-ray burst**
- **Burst-disk interactions**
- **Summary**

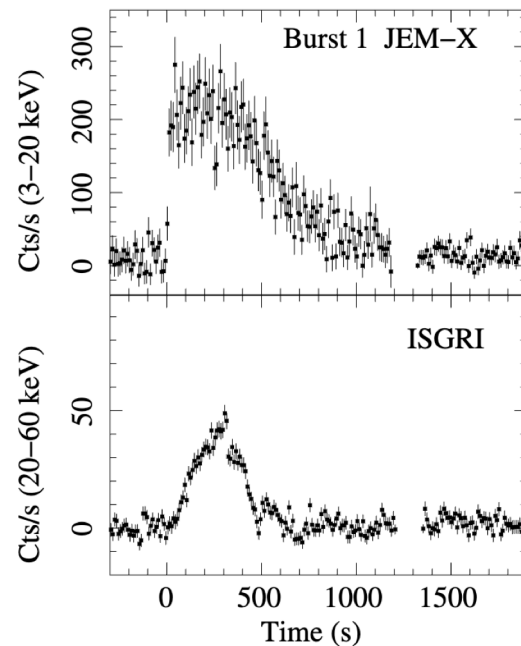
Neutron star mass and radius measurements

- **Gravitational wave**
- **Gravitational redshift on NS surface**
- **Pulse profile modeling**
- **Thermal emission from quiescent LMXBs and INS**
- **Thermonuclear X-ray bursts**

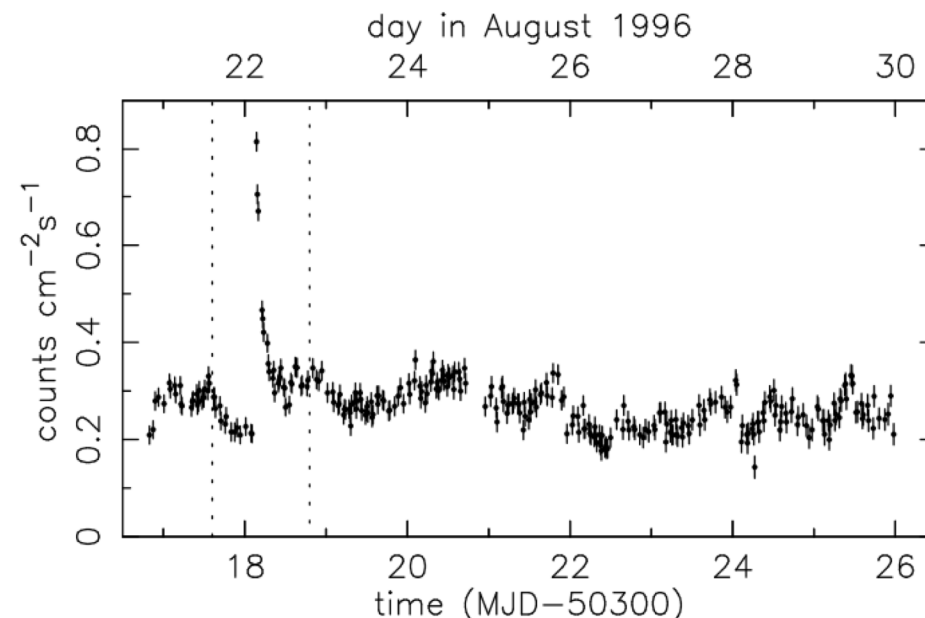
Thermonuclear X-ray burst



X-ray burst in 4U 1254-69 (In't Zand et al., 2003)



Falanga et al. 2008



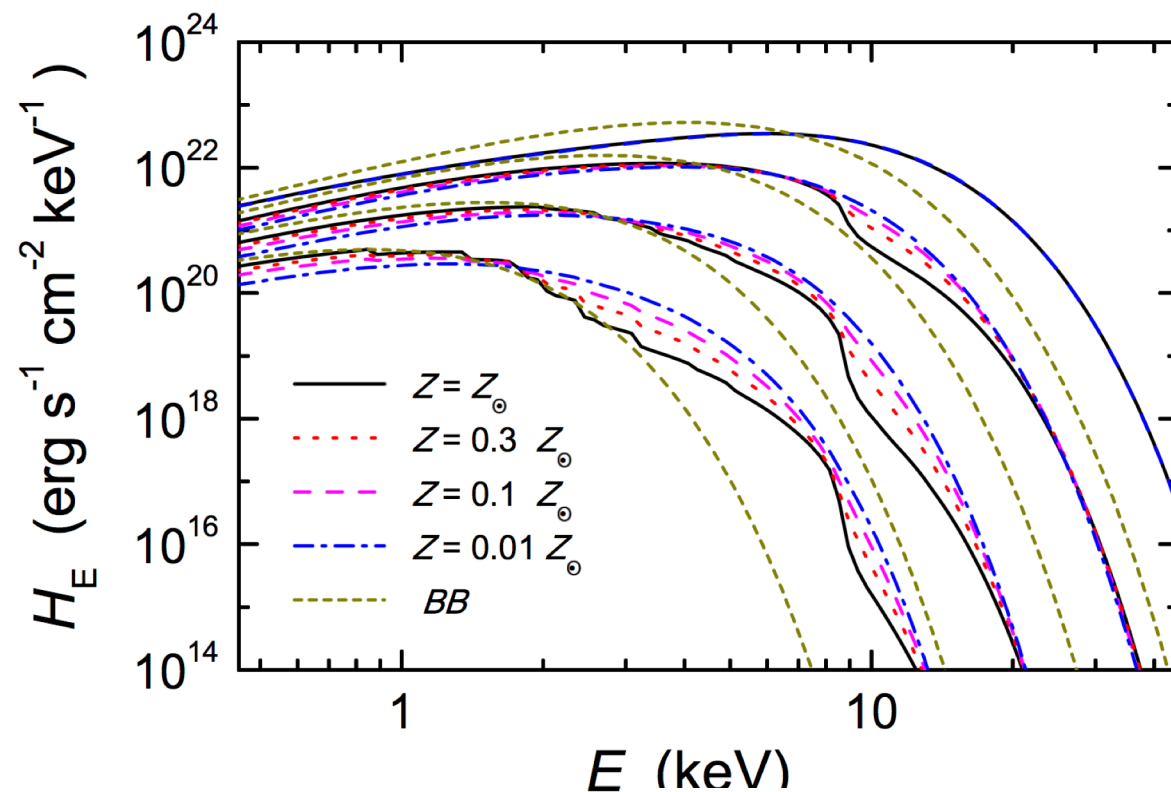
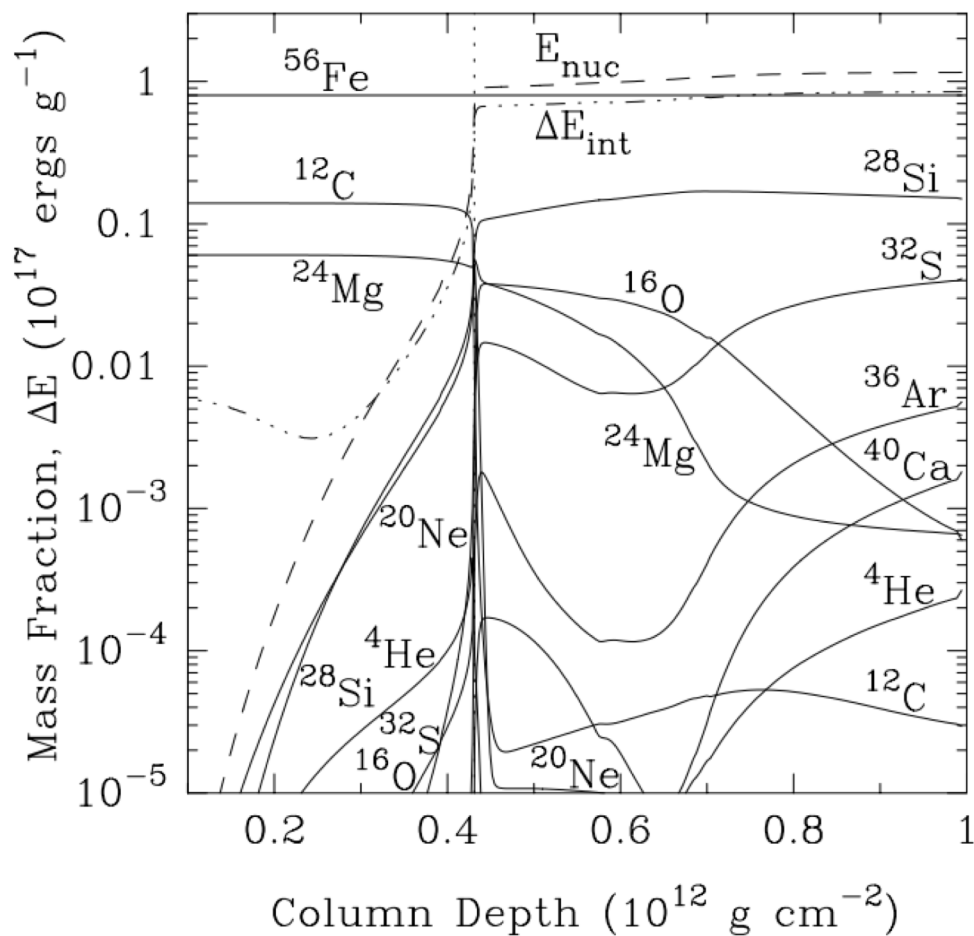
4U 1735-44, Cornelisse et al 2000

H burning via: CNO cycle **6.7 MeV/u**
He burning via: $\alpha + \alpha + \alpha \rightarrow {}^{12}\text{C}$ **0.6 MeV/u**

Low accretion rate
Helium burning in deep layer

Carbon burning
 10^3 longer, $1/10^3$ rare, 10^3 energetic

Thermonuclear X-ray burst

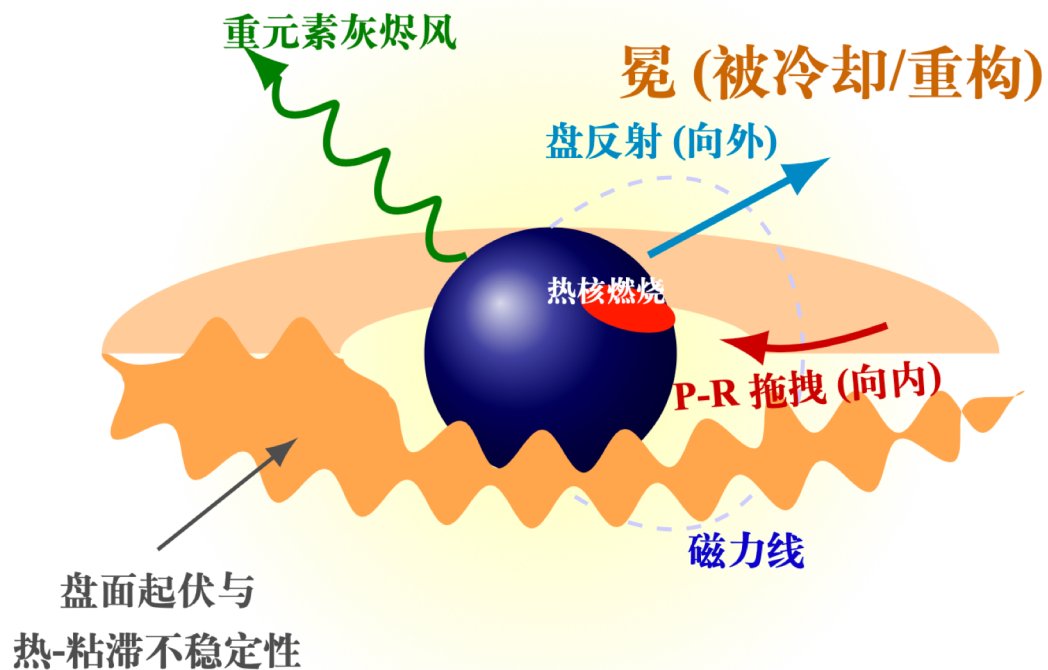


$$F_{\text{TD}} = \frac{GMc}{k_{\text{es}}D^2} \left(1 - \frac{2GM}{Rc^2}\right)^{1/2}, \quad A = \frac{R^2}{D^2 f_c^4} \left(1 - \frac{2GM}{Rc^2}\right)^{-1},$$

superburst, Weinberg & Bildsten 2007

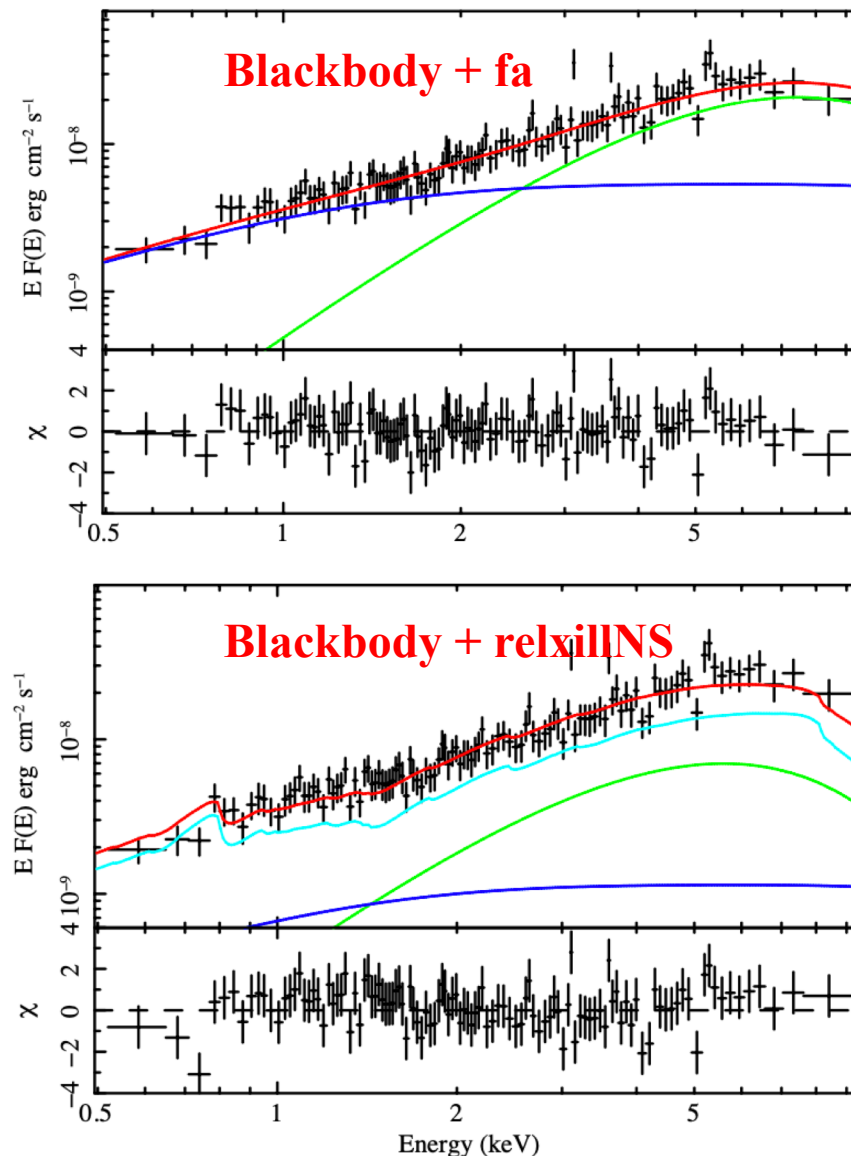
Suleimanov et al. 2011, 2012

Burst-disk interactions



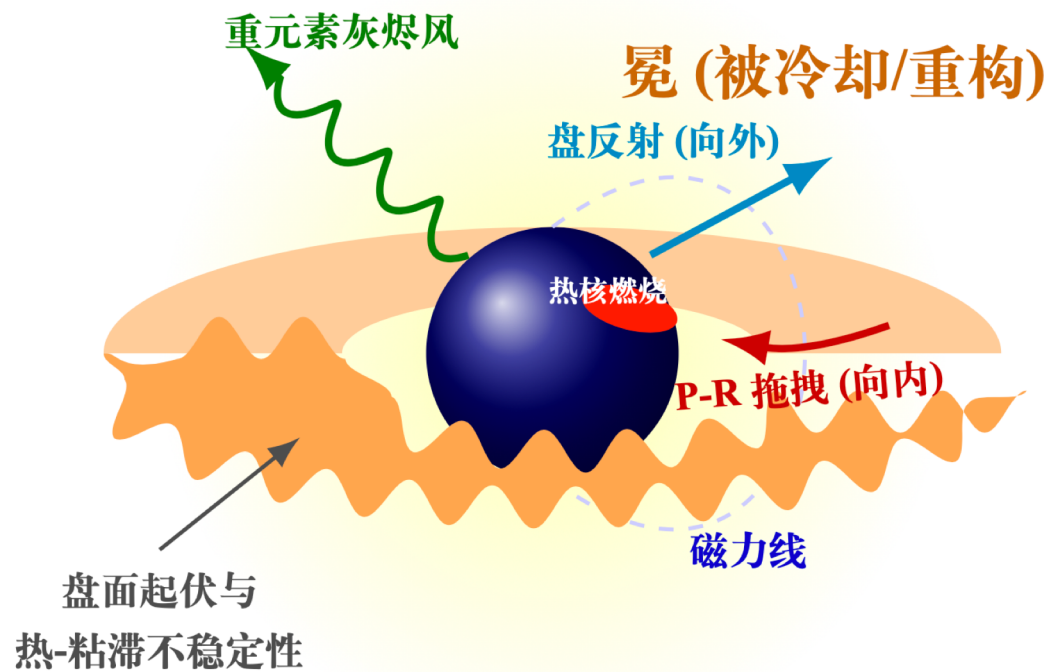
“暴—盘—冕” 相互作用物理图像

Zhao (赵国英), [Li et al. 2022, A&A](#)
Lu (路永琪), [Li, et al. 2023, A&A](#)

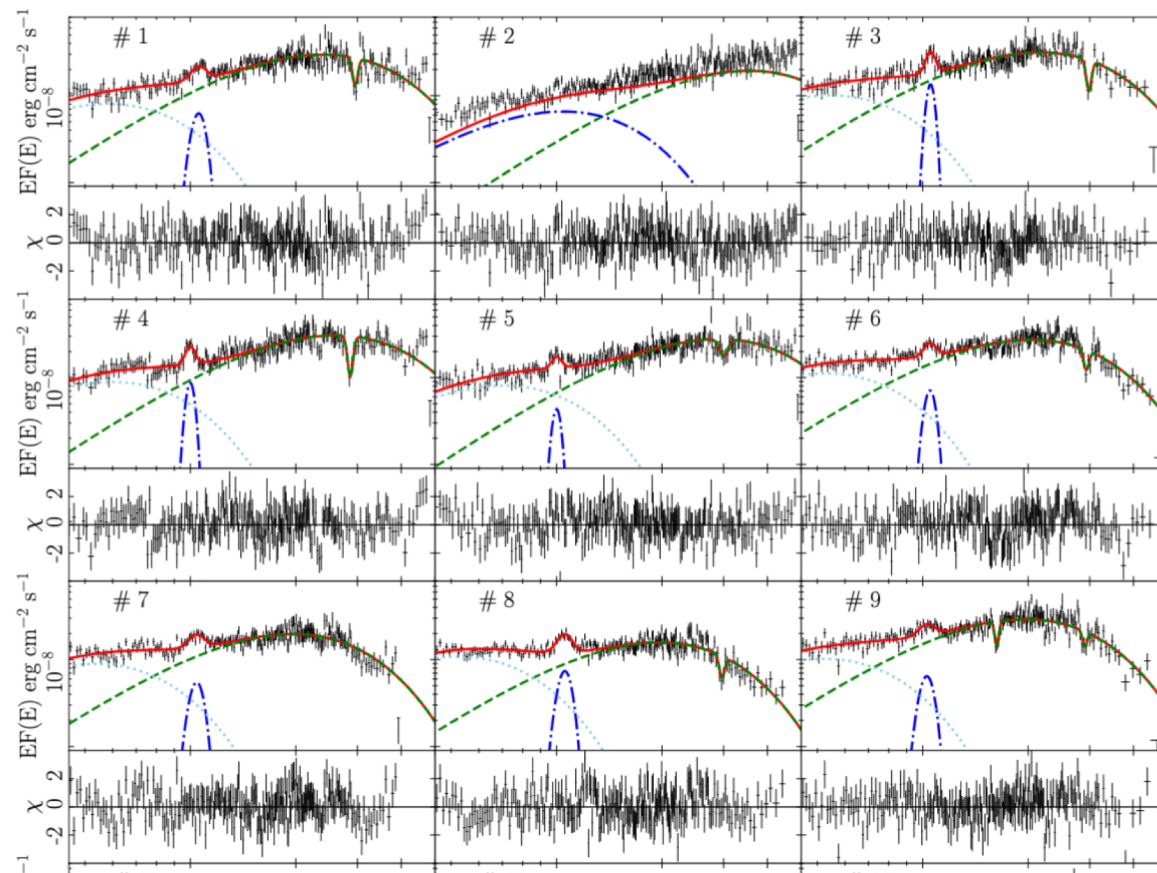


Burst-disk interactions

4U 1820-30: 1 keV发射线 (Fe L shell), 1.6 keV (Fe, Mg XI, Cr XXIV), 3 keV吸收线 (He-like S XV)



“暴—盘—冕” 相互作用物理图像

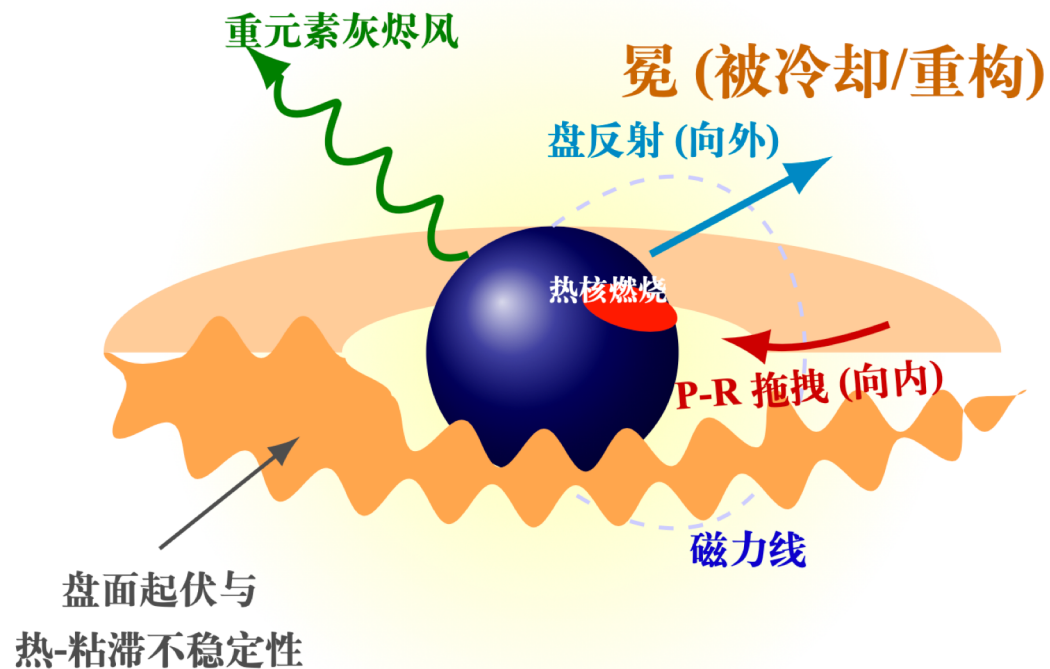


Yu (余文辉), Li, et al. 2024, A&A

Yu (余文辉), Li, et al. 2025, A&A

Burst-disk interactions

SRGA J144459.2-604207: clocker burster, AMXP, 60 X-ray bursts by HXMT



“暴—盘—冕” 相互作用物理图像

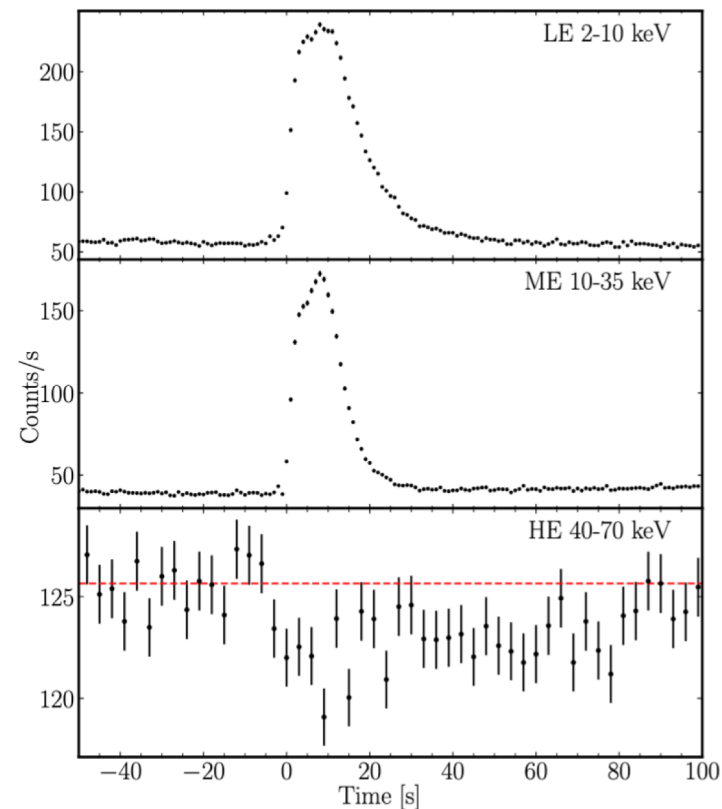
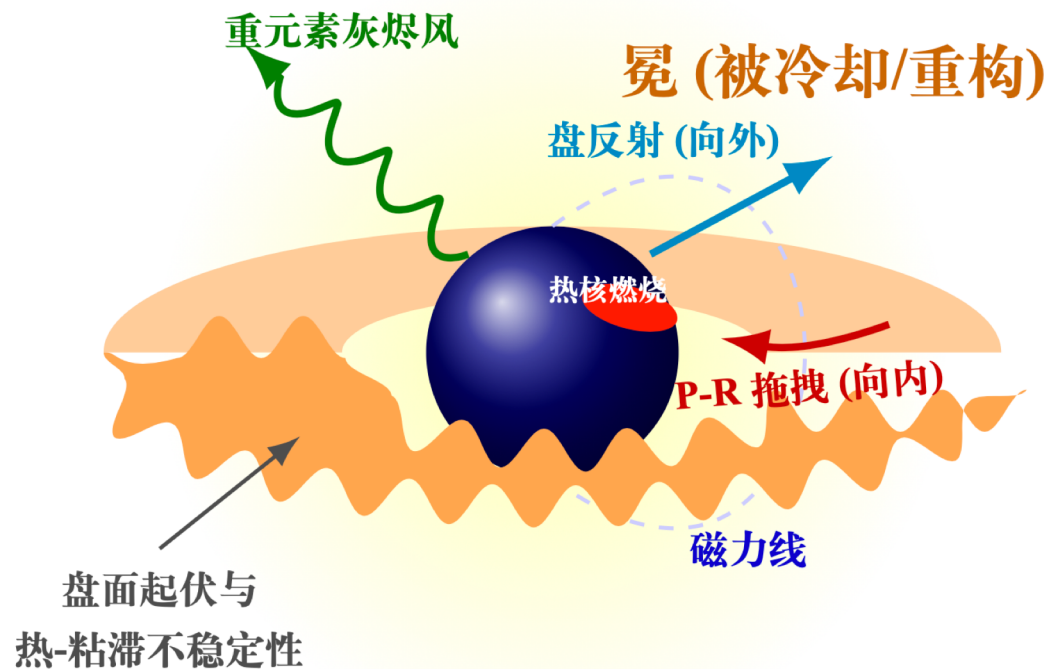


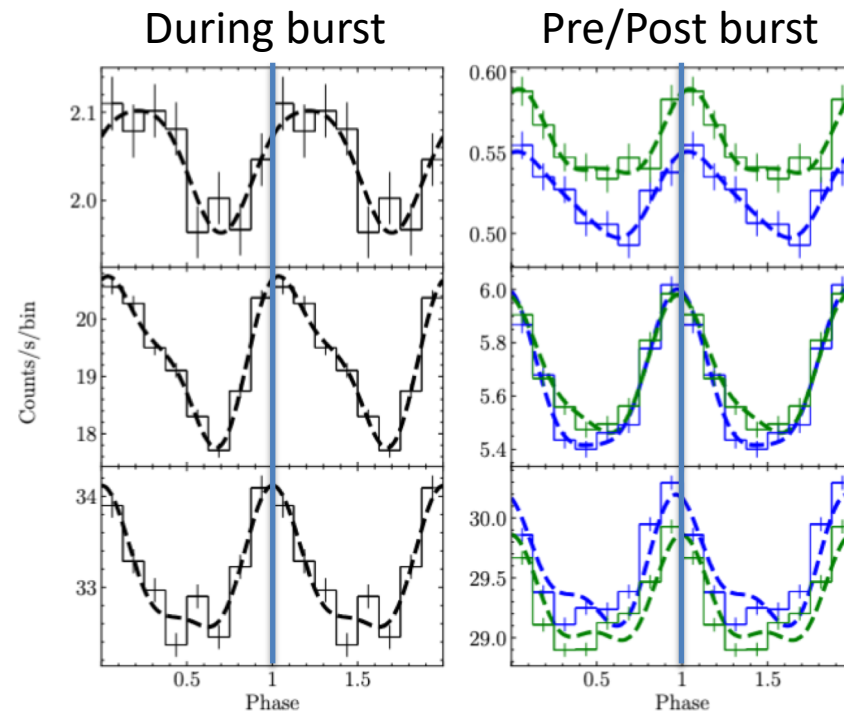
Figure 6. From top to bottom panels, we show the LE, ME, and HE light curves during bursts in 2–10 keV, 10–35 keV, and 40–70 keV, respectively. The binsize is 1 s for LE and ME, 3 s for HE.

Burst-disk interactions

SRGA J144459.2-604207: clocker burster, AMXP, 60 X-ray bursts by HXMT



“暴—盘—冕” 相互作用物理图像



IXPE, 2-8 keV

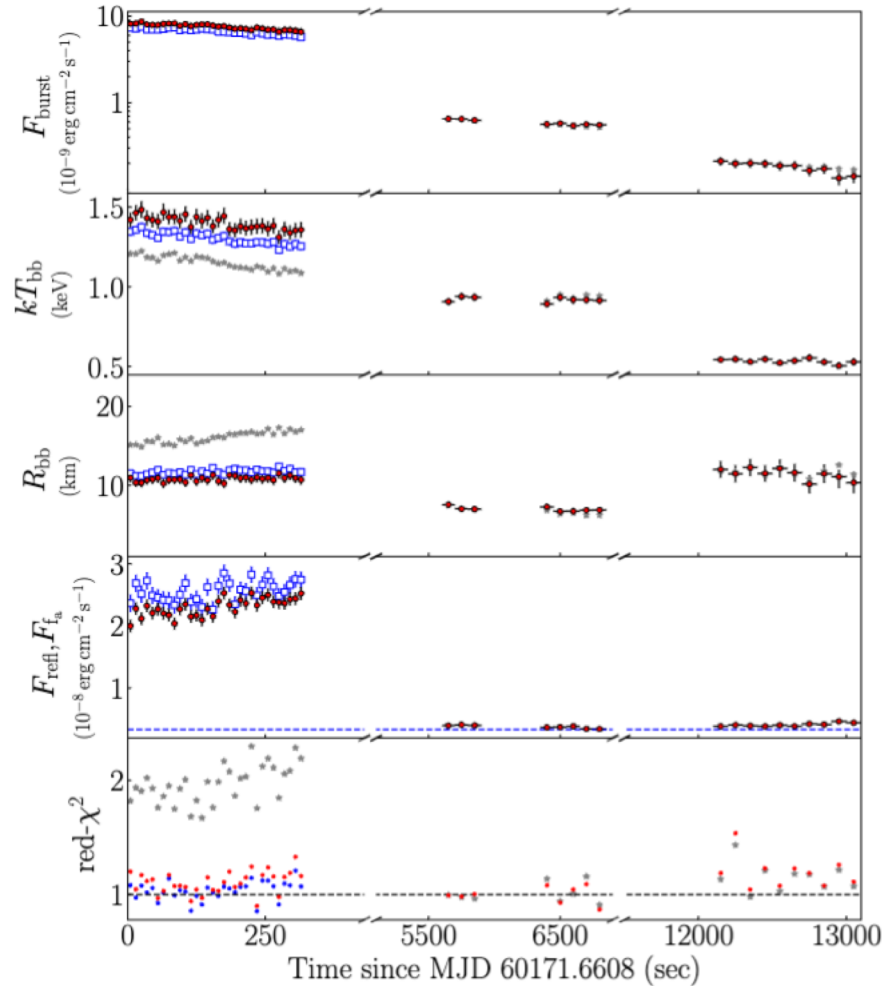
HXMT/ME, 5-30 keV

HXMT/HE, 20-60 keV

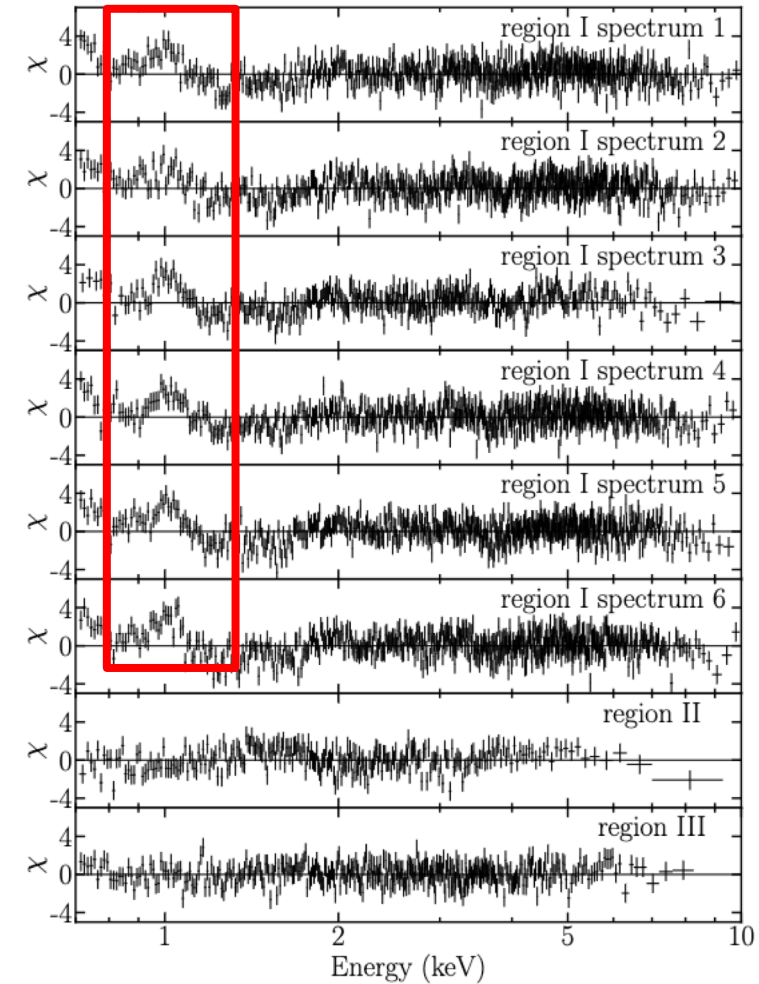
Li, et al. 2025, ApJ

Burst-disk interactions: long bursts

4U 1850-087: 1 keV Fe emission line, from inner accretion disk reflection



Emission line at 1 keV



Burst-disk interactions: long bursts

4U 1820-30: Superburst emptied the inner accretion disk, causing the deficit of persistent emission.

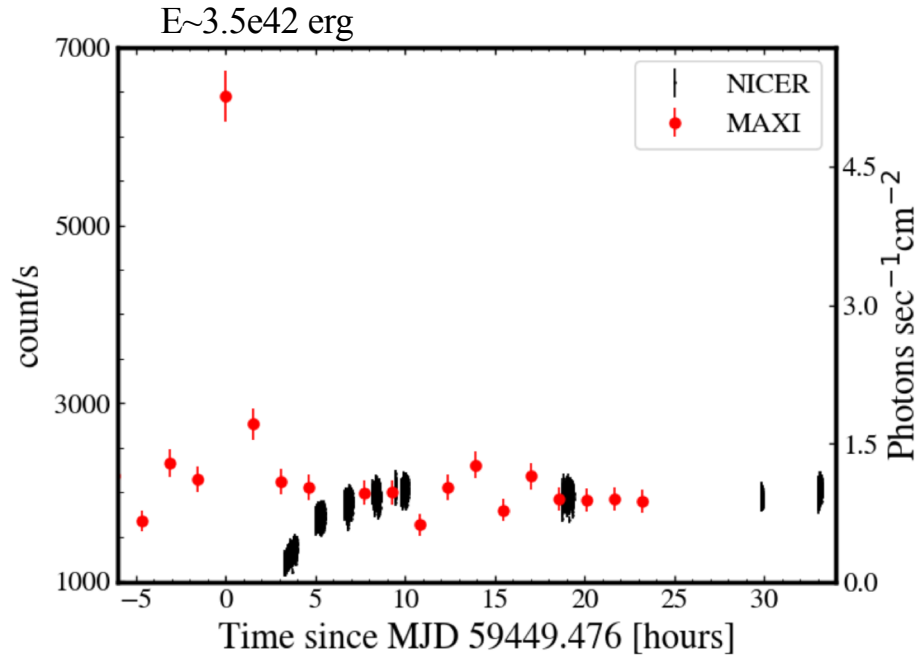


Figure 1. The light curve of the superburst from 4U 1820-30 observed by NICER (with time bin size of 1 s in 0.5–10 keV, black points) in units of counts/s and MAXI (~ 250 s, 2–20 keV, red points) in units of photons $\text{sec}^{-1} \text{cm}^{-2}$.

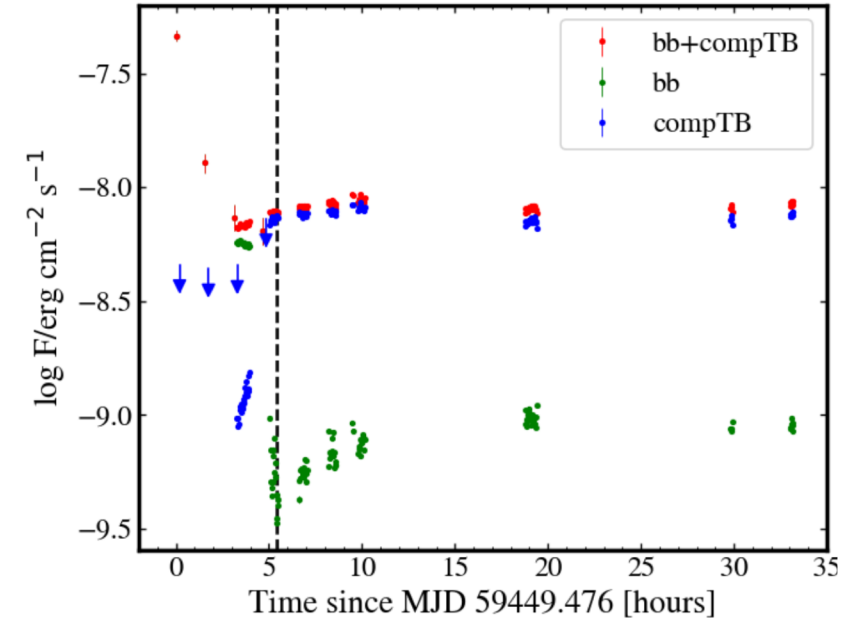


Figure 6. The variation of flux during the entire Obs. Ids. 05 and 06. The red, green, and blue points represent the total X-ray, the blackbody, and the Comptonization flux, respectively. The dotted line marks the moment of the lowest blackbody flux.

Burst-disk interactions: long bursts

4U 1820-30: Superburst emptied the inner accretion disk, causing the deficit of persistent emission.

$$\Sigma = 2.7 \times 10^5 \alpha^{-4/5} \left(\frac{M_{\text{NS}}}{1.4 M_{\odot}} \right)^{-2/5} \left(\frac{\dot{M}}{7.7 \times 10^{17} \text{ g s}^{-1}} \right)^{3/5} \times \left(\frac{D}{8.4 \text{ kpc}} \right)^{6/5} \left(\frac{R}{r_g} \right)^{-3/5} J(R)^{3/5} \text{ g cm}^{-2}, \quad (3)$$

where R denotes the outer radius of the accretion disk, $J(R) = 1 - (6r_g/R)^{1/2}$, $r_g = GM_{\text{NS}}/c^2$, and $\alpha = 0.1$ is the Shakura–Sunyaev viscosity parameter. The accretion rate is $\dot{M} = 4\pi D^2 F / \eta c^2 = 7.7 \times 10^{17} (D/8.4 \text{ kpc})^2 \text{ g s}^{-1}$, where the persistent bolometric flux is $8.2 \times 10^{-9} \text{ erg s}^{-1} \text{ cm}^{-2}$, and the accretion efficiency η is assumed to be 0.1. Based on this model, we estimated the gravitational potential energy, $\sim 6 \times 10^{39} \text{ erg}$, of the disk material located between $6r_g$ and $1000r_g$ under the Schwarzschild metric for an NS with a mass of $1.4 M_{\odot}$ and radius of 10 km. If the peak flux of the superburst

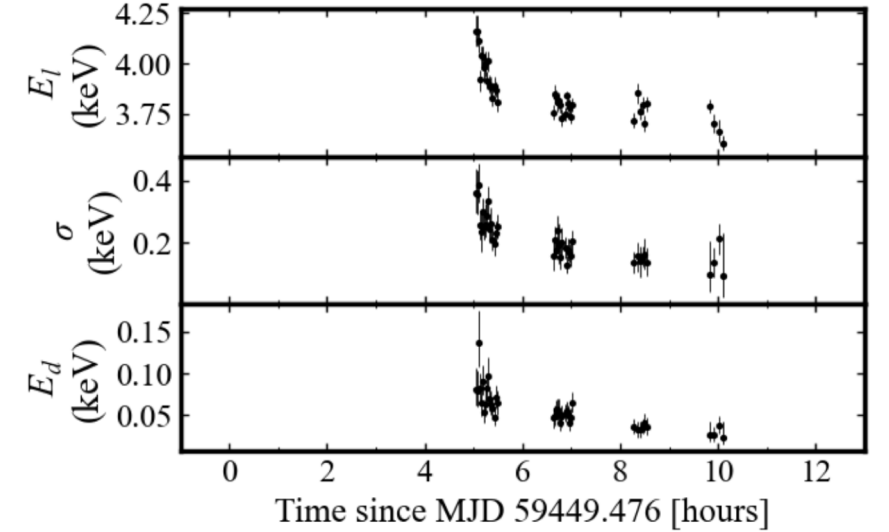
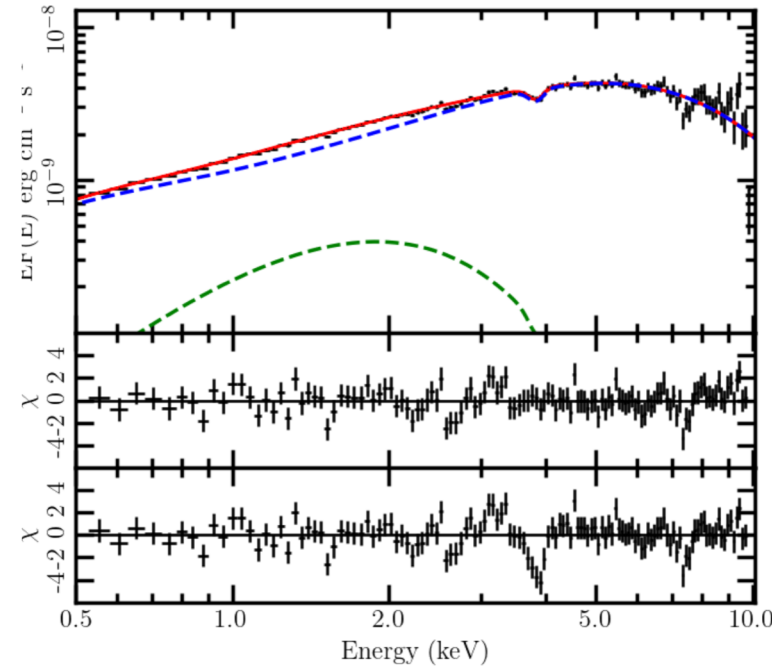
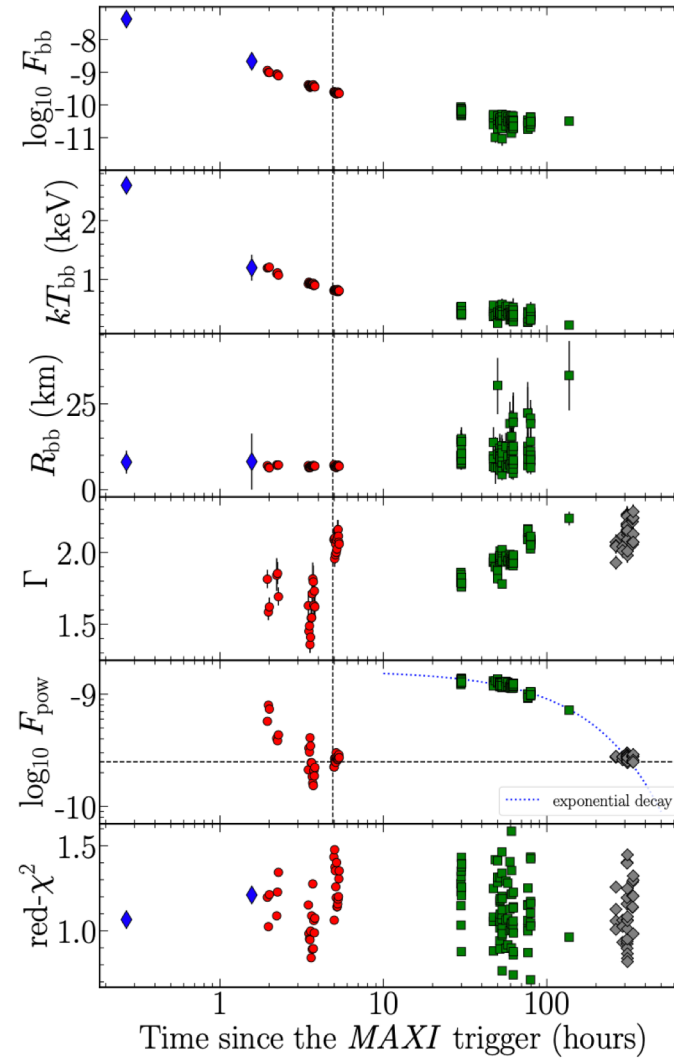
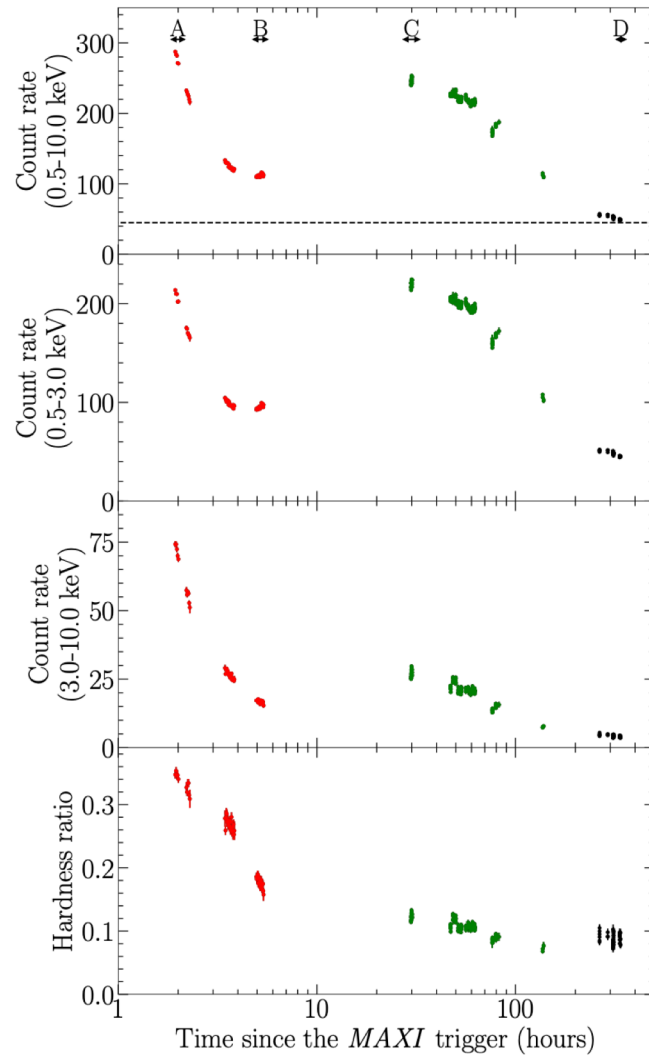


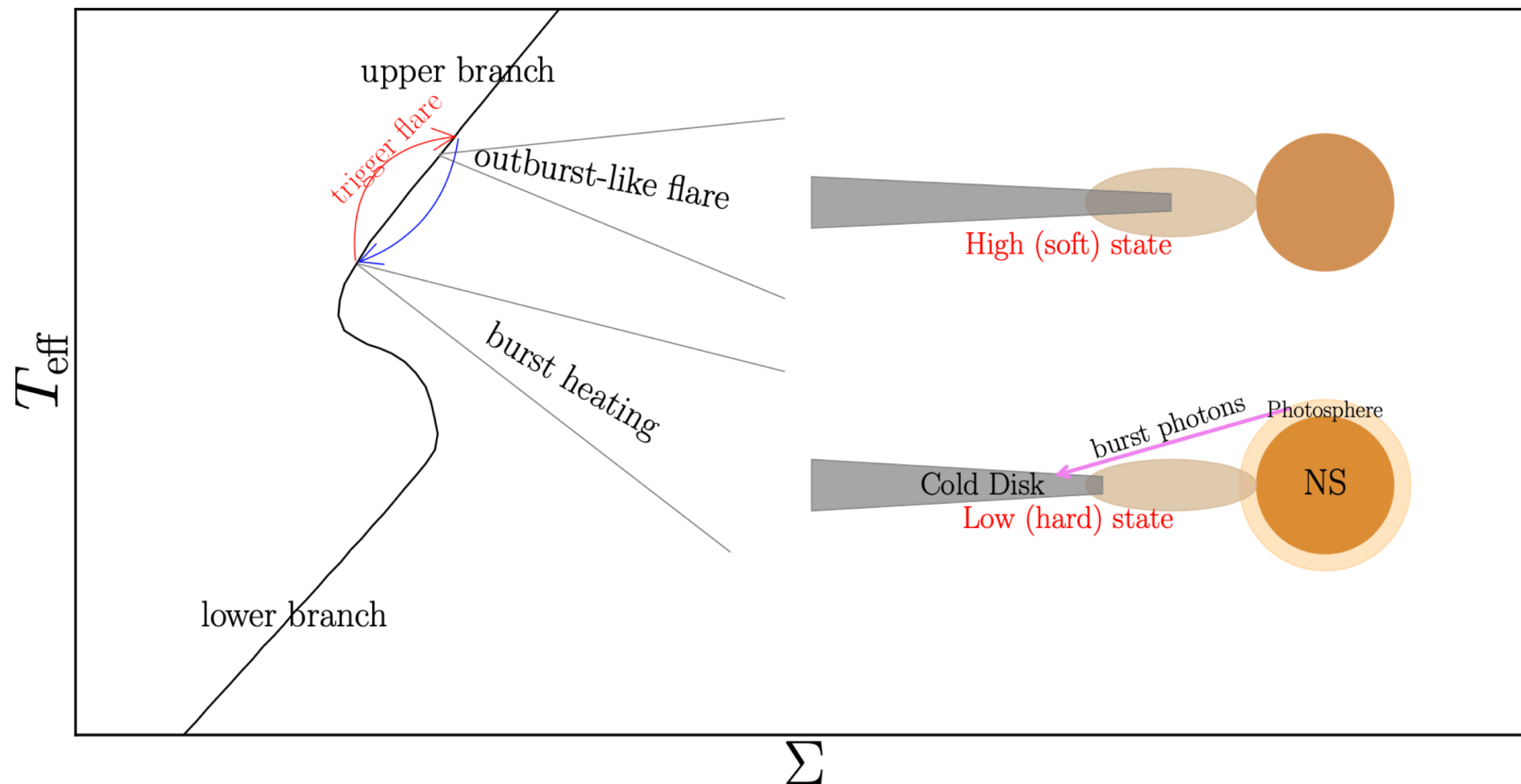
Figure 9. The evolution of the absorption line energy, width, and depth.

Burst-disk interactions: long bursts

MAXI J0911–655



Burst-disk interactions: long bursts



Summary

- **Burst-disk interactions**
 - **Reflection**
 - **Poynting-Robertson effect**
 - **Corona cooling**
 - **Empty the inner accretion disk**
 - **Driven Thermal-viscous Instability of Accretion Disk**

谢谢大家！