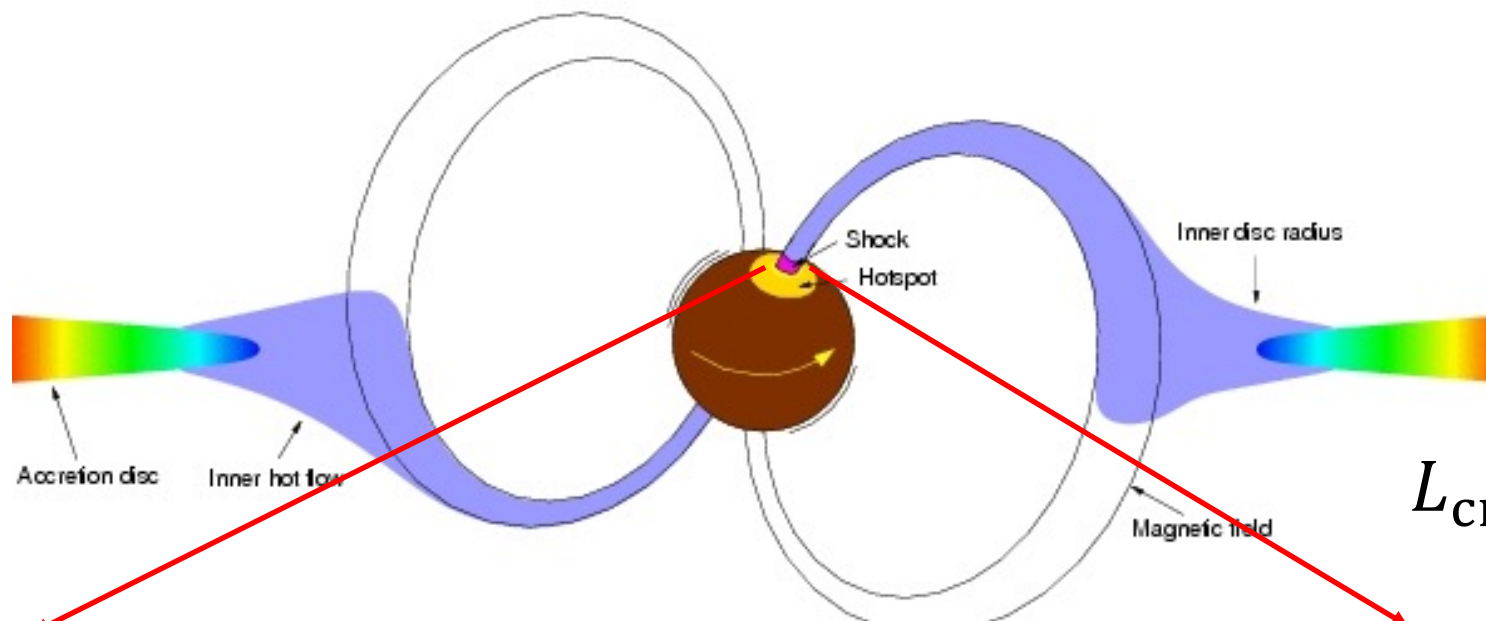


Accretion regimes in accreting X-ray pulsars

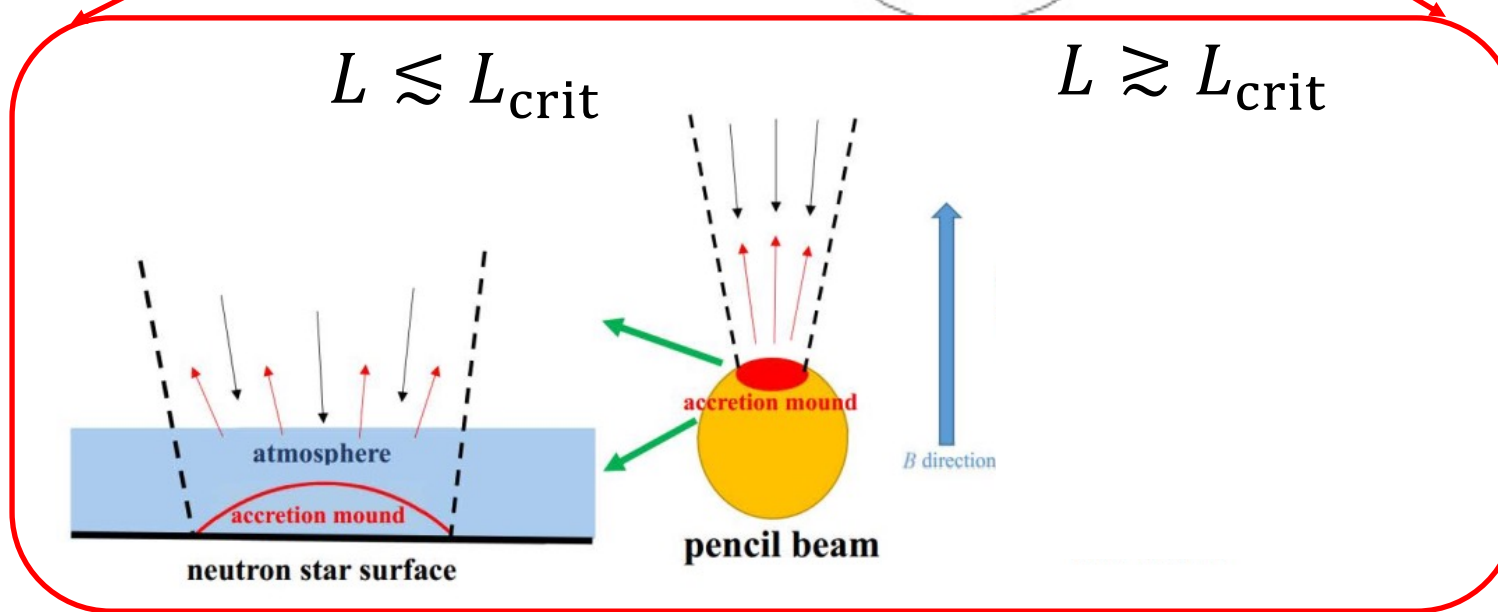
Speaker: Long Ji

on behalf of H. Xiao (SYSU), Q.-C. Shui, S. Zhang, Zhang, S.-N. (IHEP),
V. Doroshenko, P.-J. Wang, L.-D. Kong, A. Santangelo (IAAT)

Background

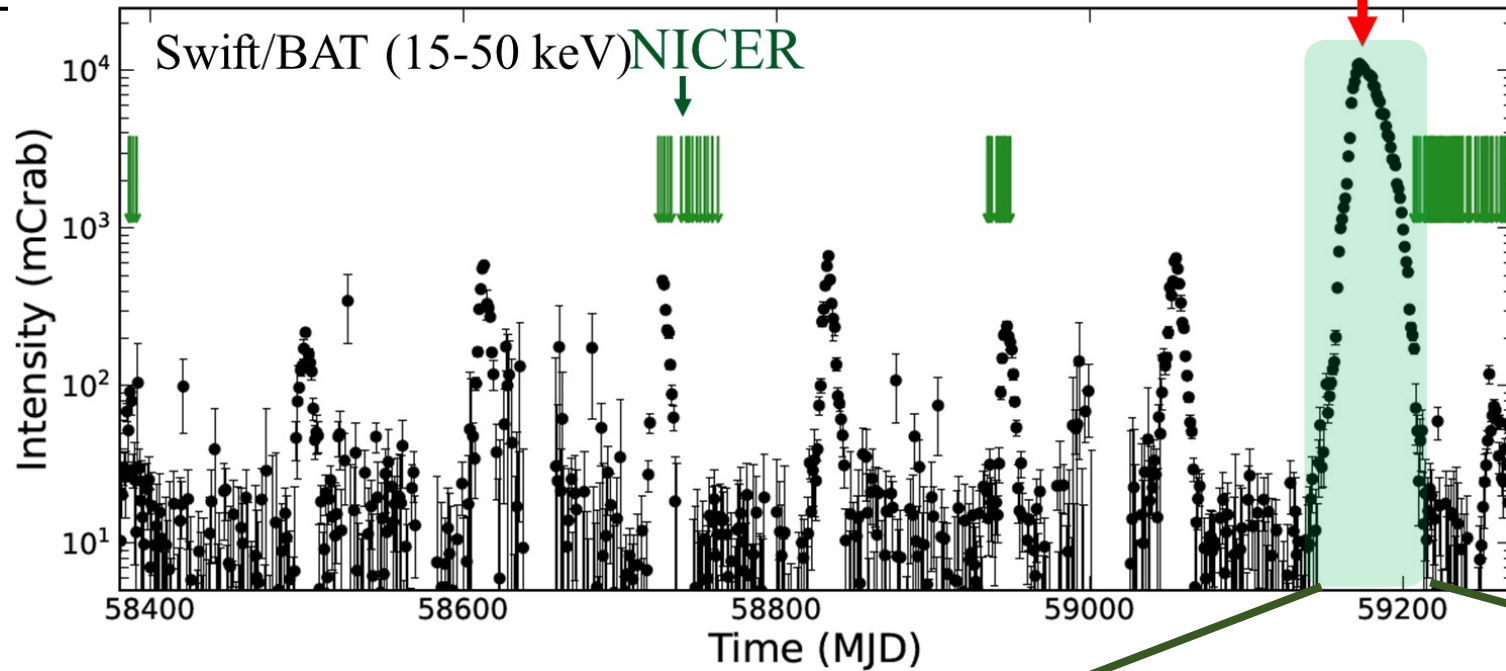


$$L_{\text{crit}} \sim 1.5 \times 10^{37} B_{12}^{16/15}$$





Outbursts in 1A 0535+262

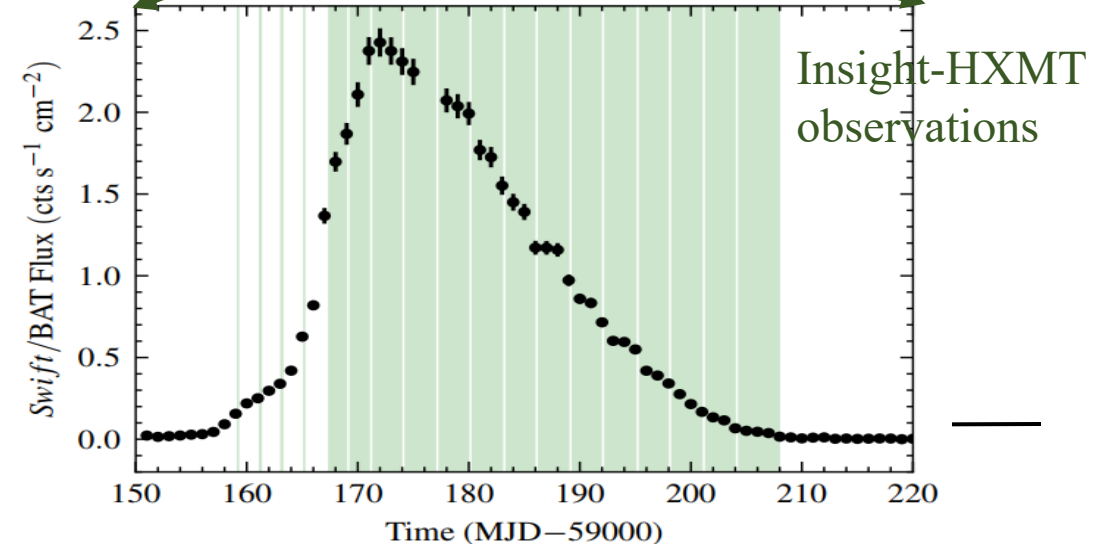


Be X-ray binary
Distance: 2kpc
Orbital period: 111d
Period: 103s
Eccentricity: 0.47

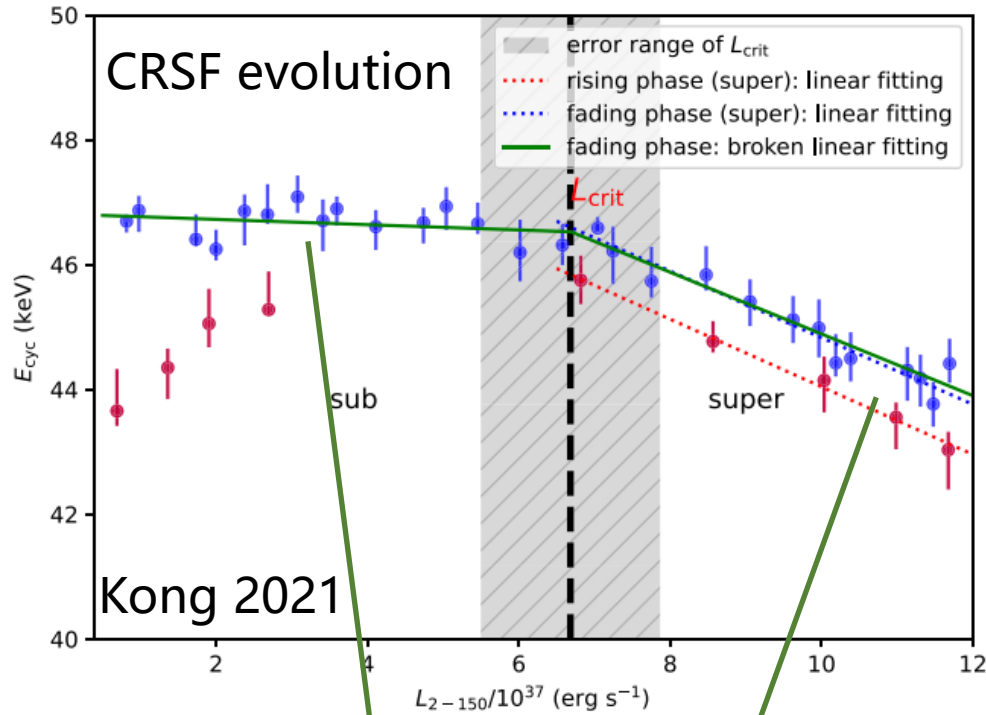
NICER+HXMT

→→→→→

**Broadband + high cadence +
broad luminosity range**

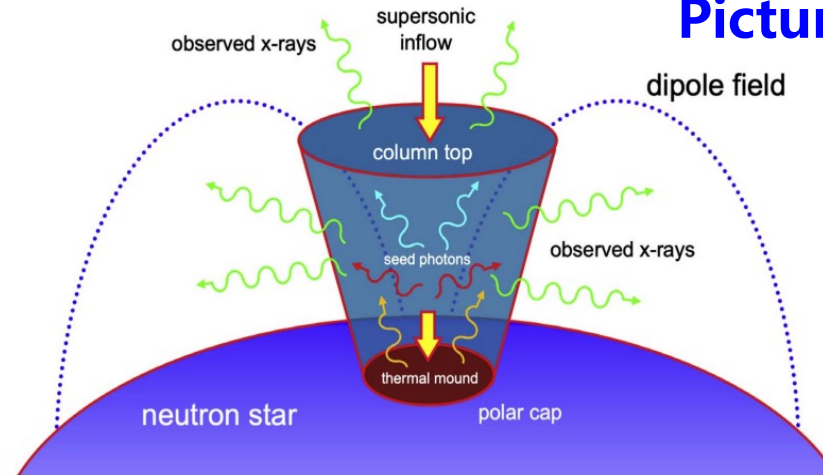


Sub-/supercritical transition



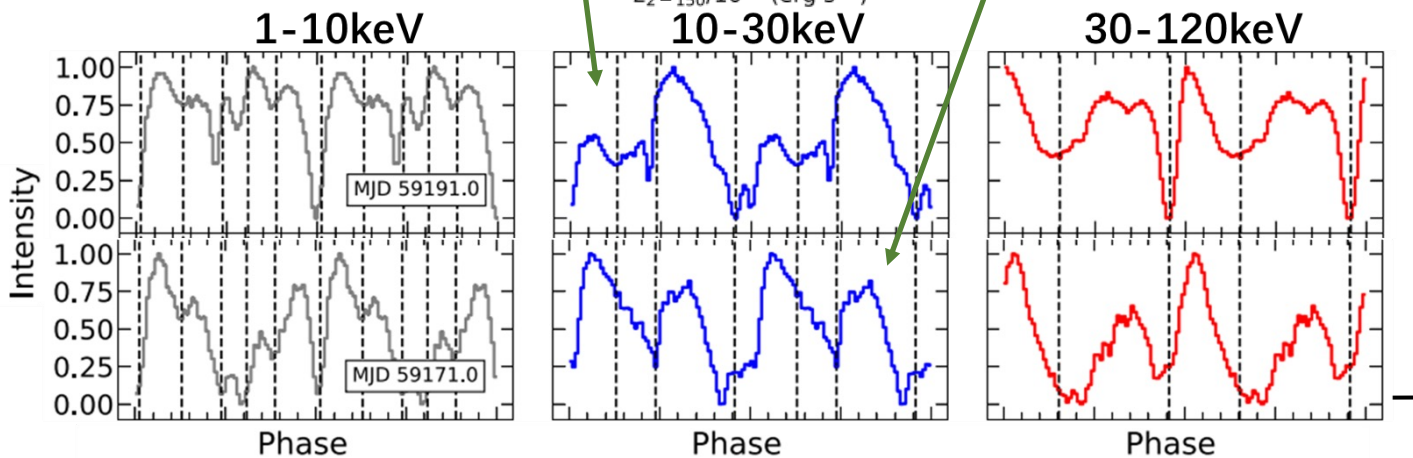
Evidence for the presence of an accretion column:

Picture 1

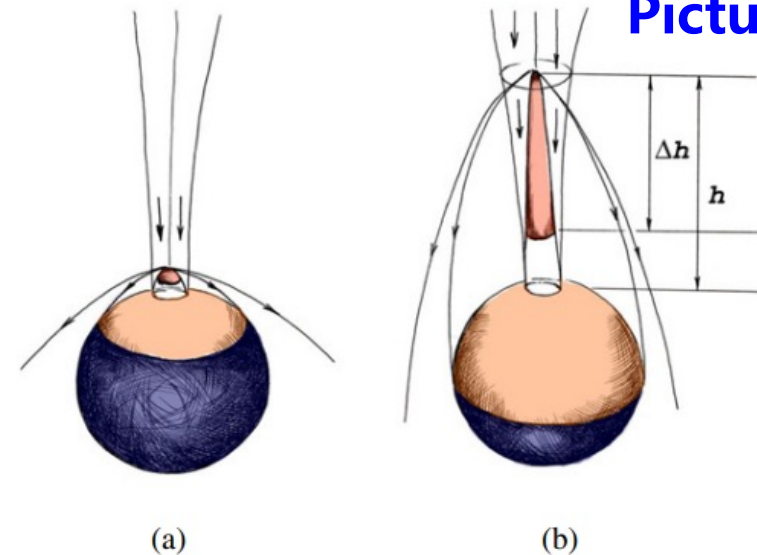


Becker 2022

Picture 2



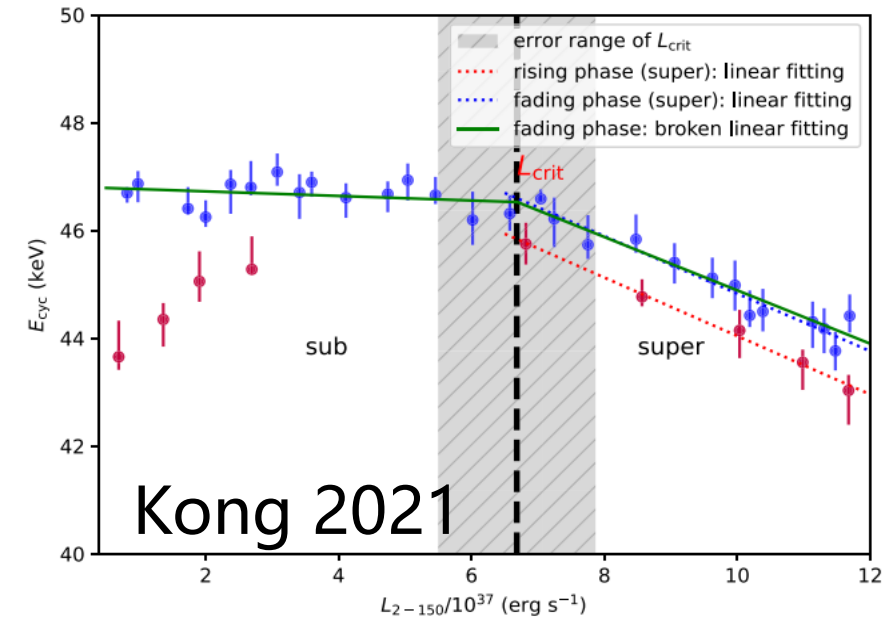
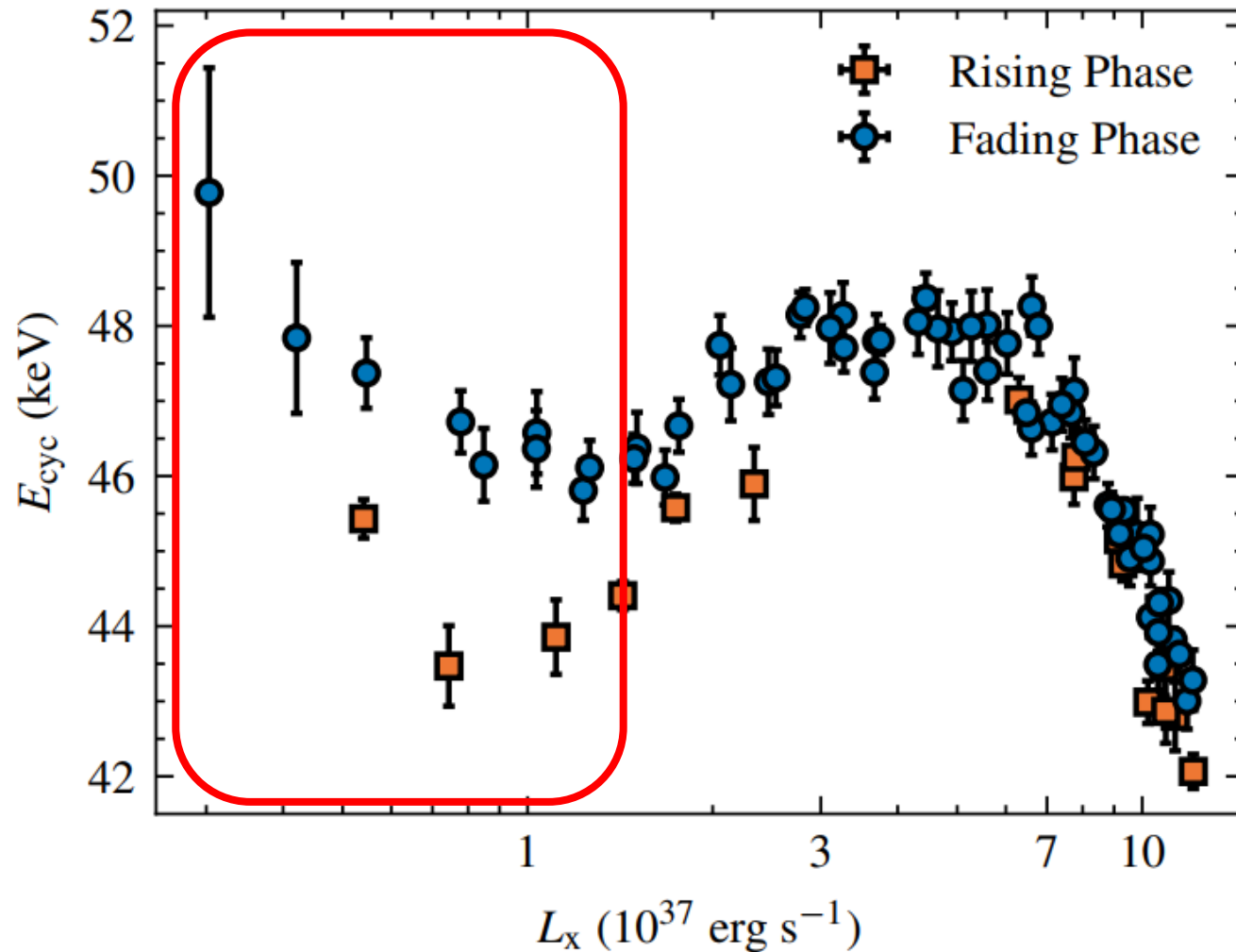
Wang 2022



Poutanen 2013

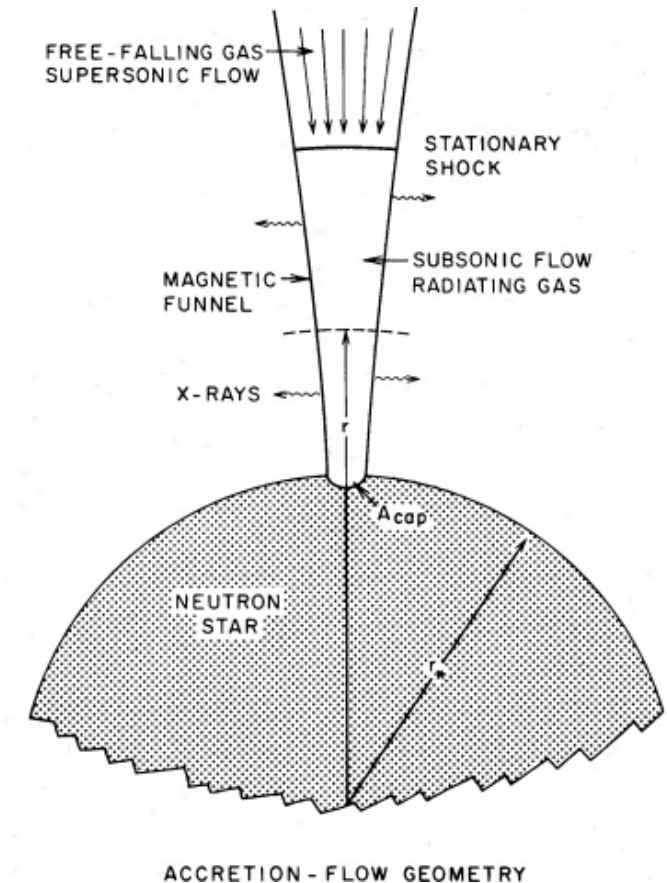
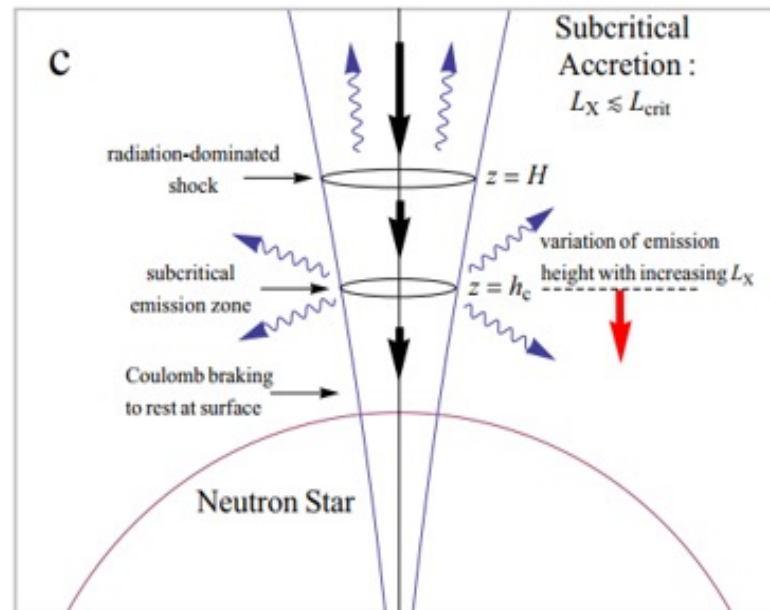
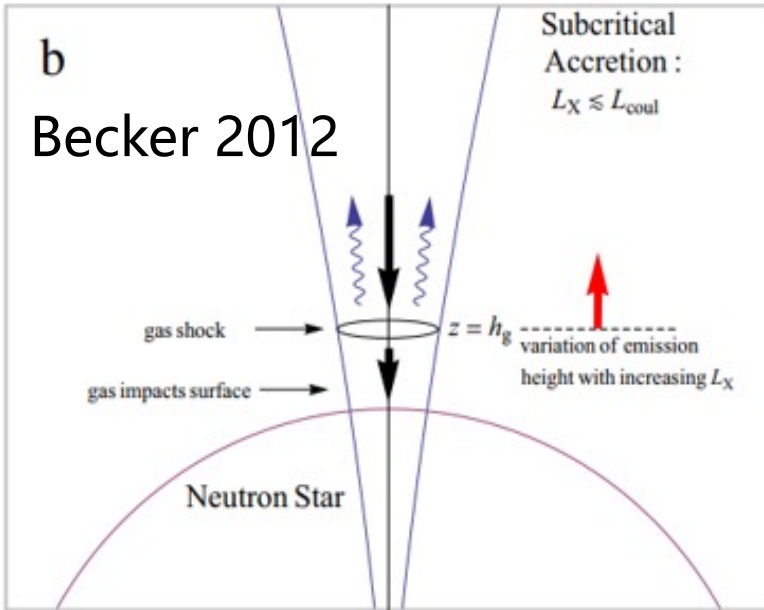
A low luminosity transition

- Pulse-to-pulse analysis



Shui submitted

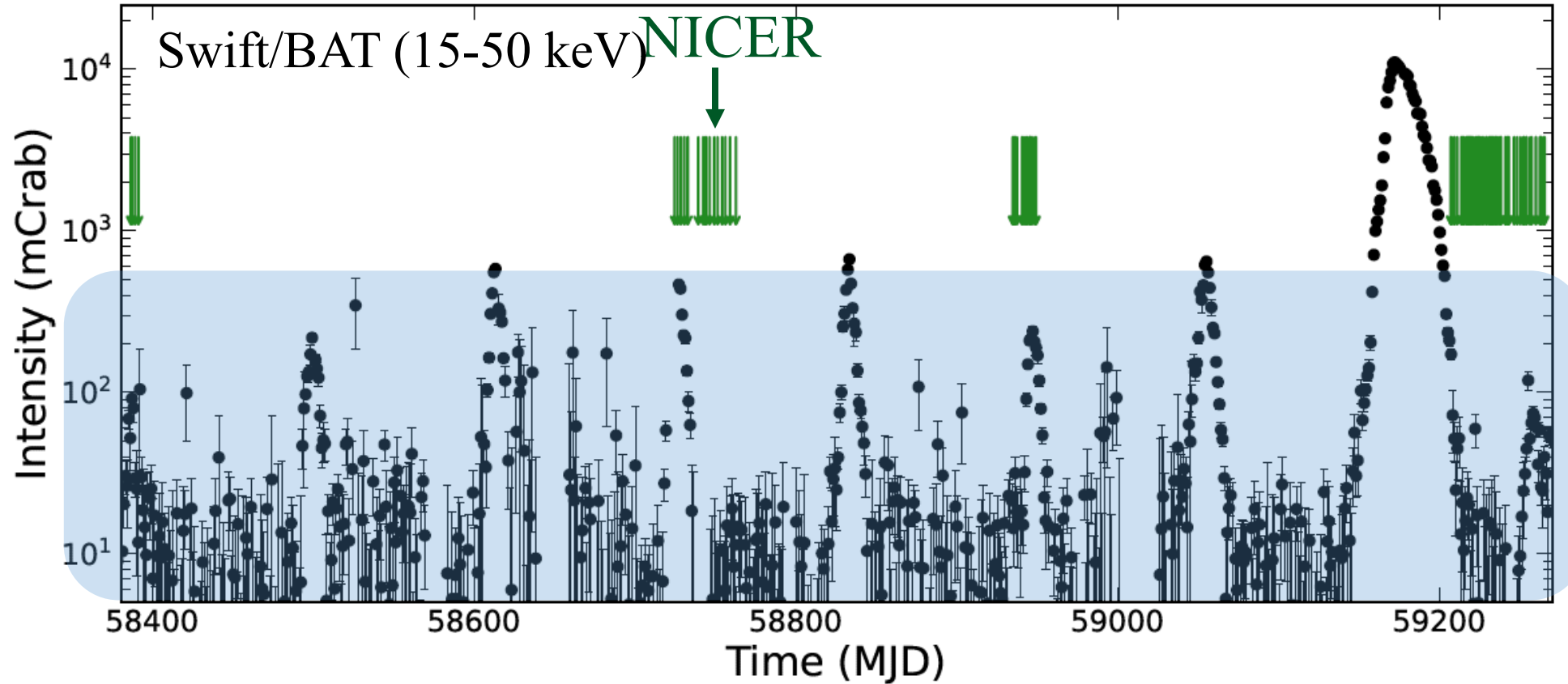
A low luminosity transition



$$L_{\text{coul}} = 1.17 \times 10^{37} \text{ erg s}^{-1} \left(\frac{\Lambda}{0.1} \right)^{-7/12} \left(\frac{\tau_*}{20} \right)^{7/12} \left(\frac{M_*}{1.4 M_\odot} \right)^{11/8} \times \left(\frac{R_*}{10 \text{ km}} \right)^{-13/24} \left(\frac{B_*}{10^{12} \text{ G}} \right)^{-1/3} .$$

Langer 1982

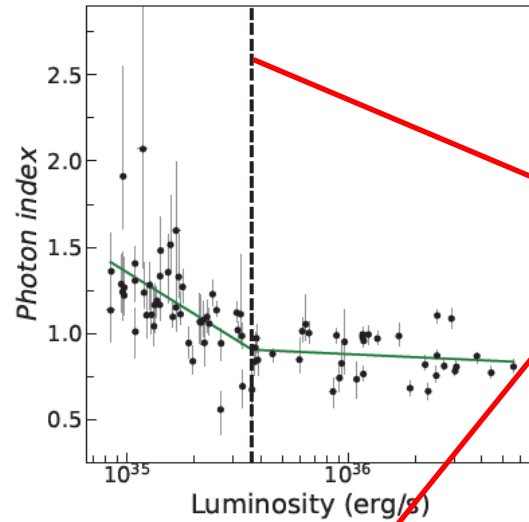
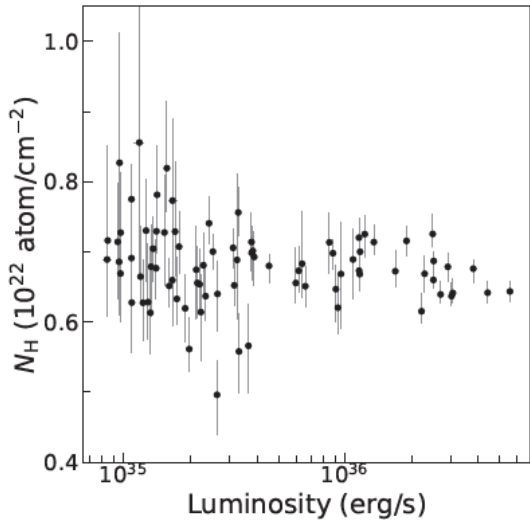
A lower luminosity transition



Xiao submitted

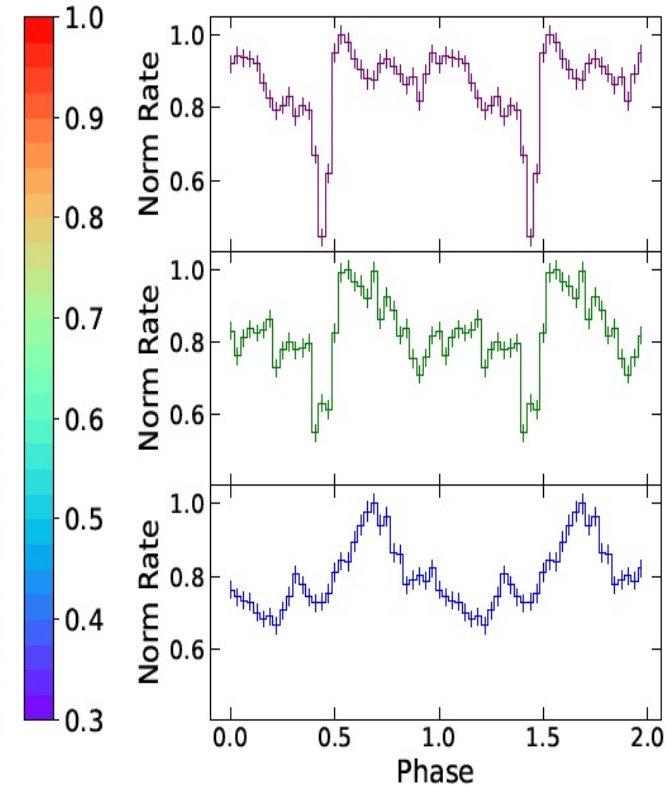
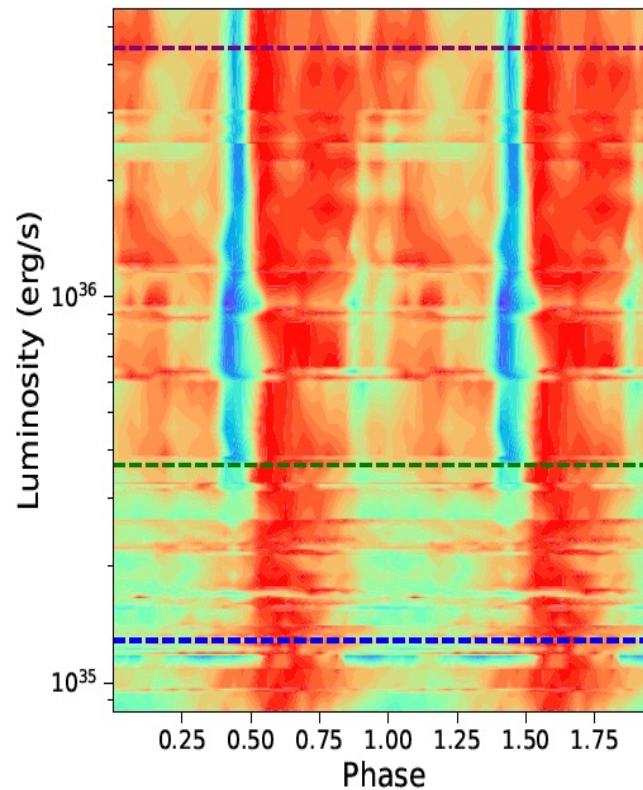
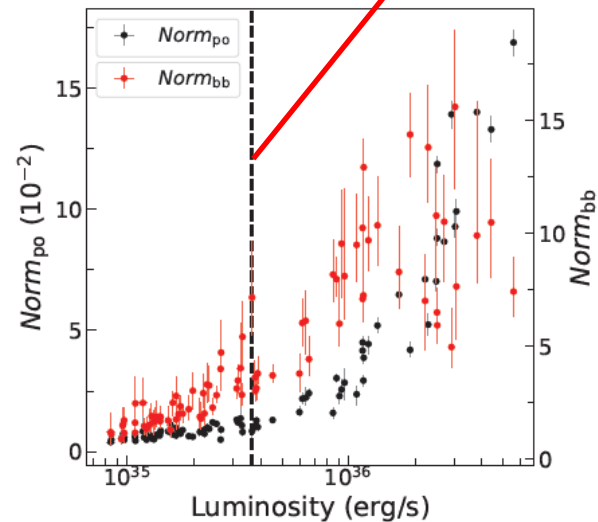
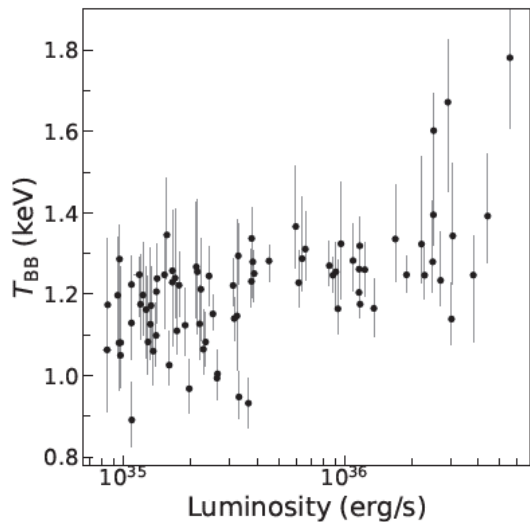
Extend to lower luminosity states using NICER observations

A lower luminosity transition



Using a simplified Model:
tbabs*(blackbody + power-law)

A transitional luminosity $L_t \sim 3.7 \times 10^{35}$ erg/



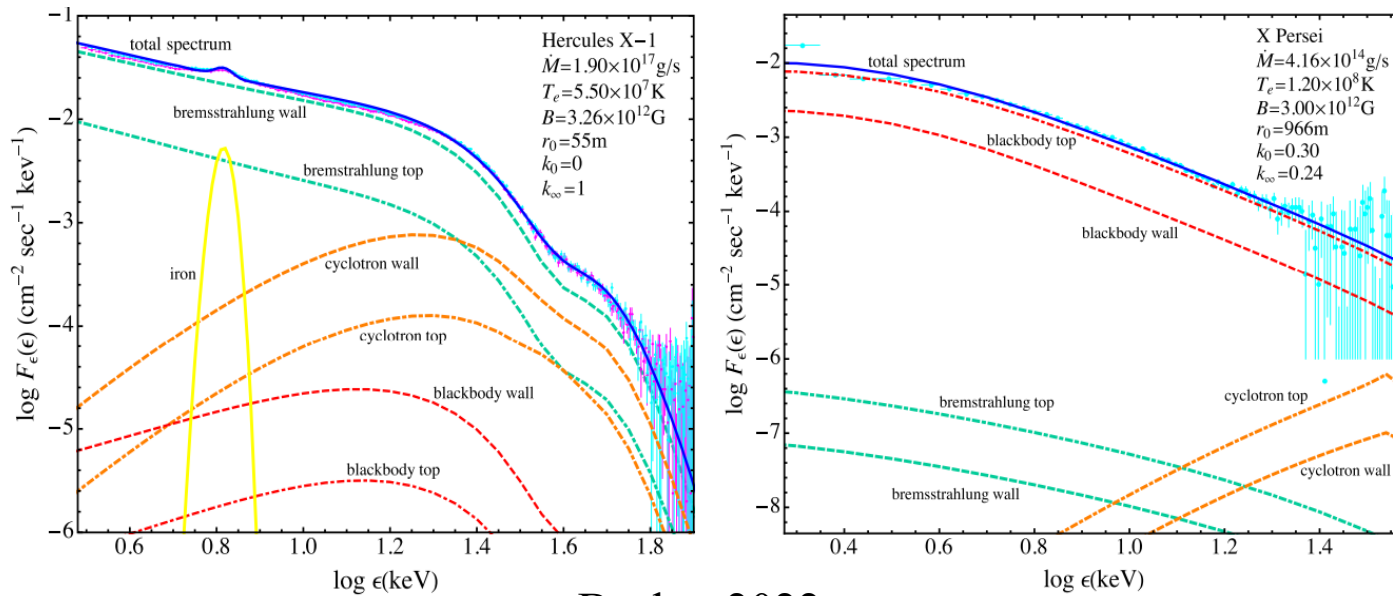
A lower luminosity transition

- Possible physical mechanisms:

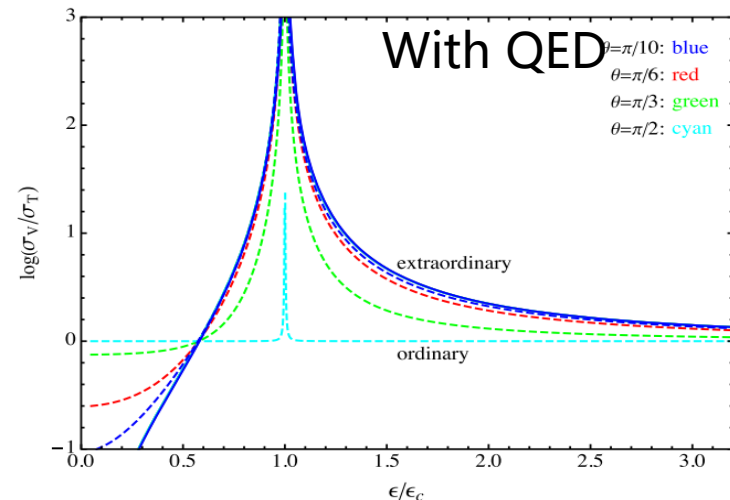
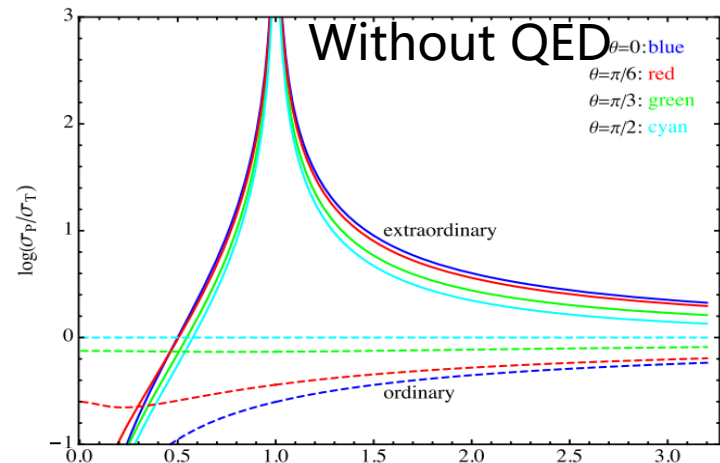
- different seed photons of Comptonization

The radiation we observed is **Compton** \otimes (**blackbody** + **bremsstrahlung** + **cyclotron**)

- vacuum polarization effect



Becker 2022





Summary

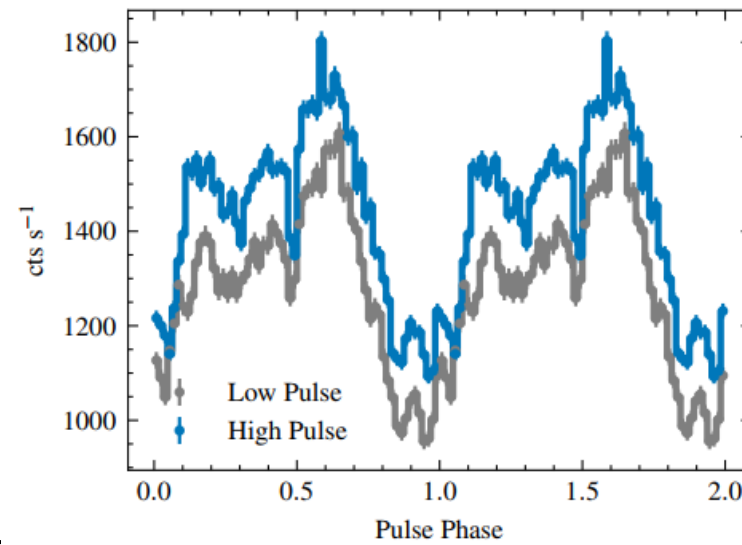
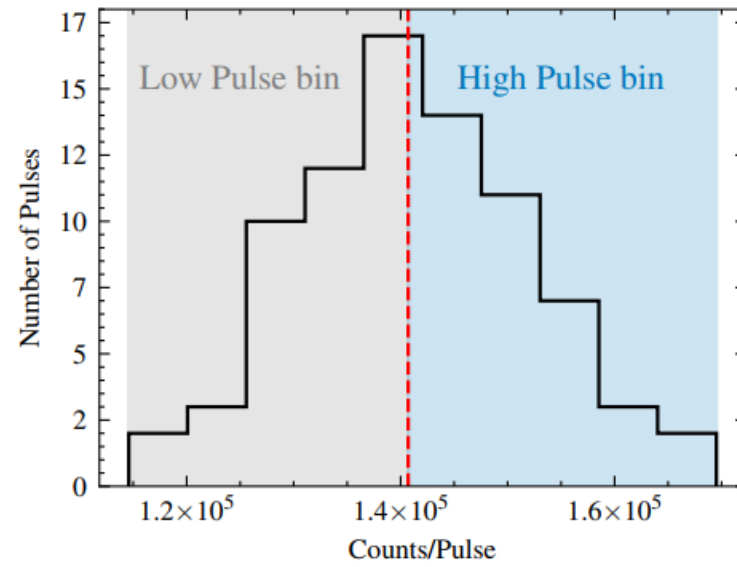
Several accretion regimes and transitional luminosities have been found in 1A 0535+26:

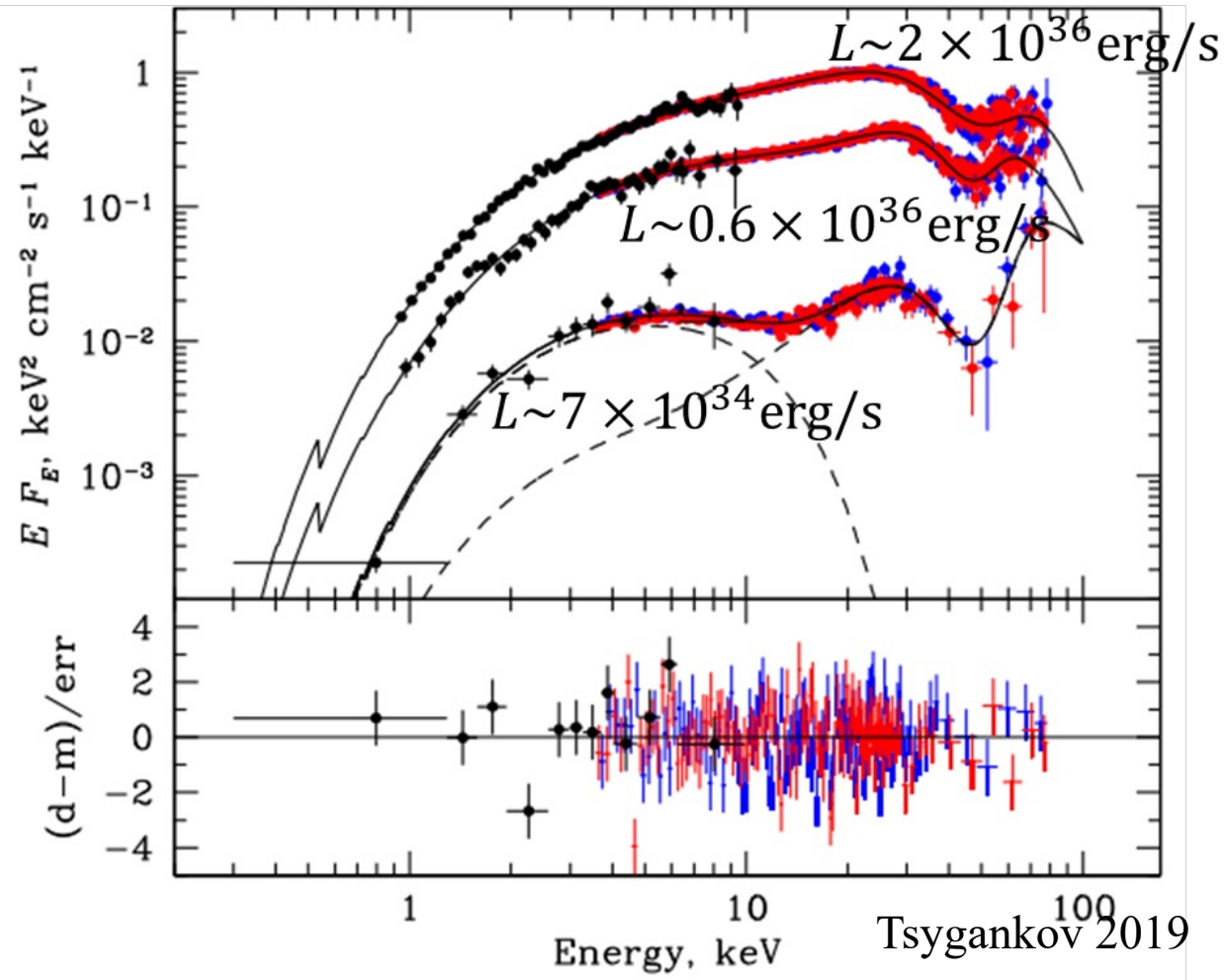
- 6.7×10^{37} erg/s: the appearance of the accretion column
- 10^{37} erg/s: probably related to the gas shock
- 4×10^{35} erg/s: different Comptonization seed photons or/and the vacuum polarization effect

Thanks!!



Backup





dielectric tensor $\epsilon = 1 + \Delta\epsilon_{\text{pl}} + \Delta\epsilon_{\text{vac}}$

$$\Delta\epsilon_{\text{pl}} = \begin{pmatrix} -\frac{w}{1-u} & \frac{iu^{1/2}w}{1-u} & 0 \\ \frac{iu^{1/2}w}{1-u} & -\frac{w}{1-u} & 0 \\ 0 & 0 & -w \end{pmatrix}$$

$$\Delta\epsilon_{\text{vac}} = \begin{pmatrix} -2\delta & 0 & 0 \\ 0 & -2\delta & 0 \\ 0 & 0 & 5\delta \end{pmatrix}$$

$$\frac{w}{\delta} = \frac{45\pi}{\alpha} \left(\frac{4\pi n_e e^2}{m_e \omega^2} \right) \left(\frac{m_e c^2}{E_{\text{cyc}}} \right)^2$$