

Comparing origins of low-frequency QPOs with spectral-timing

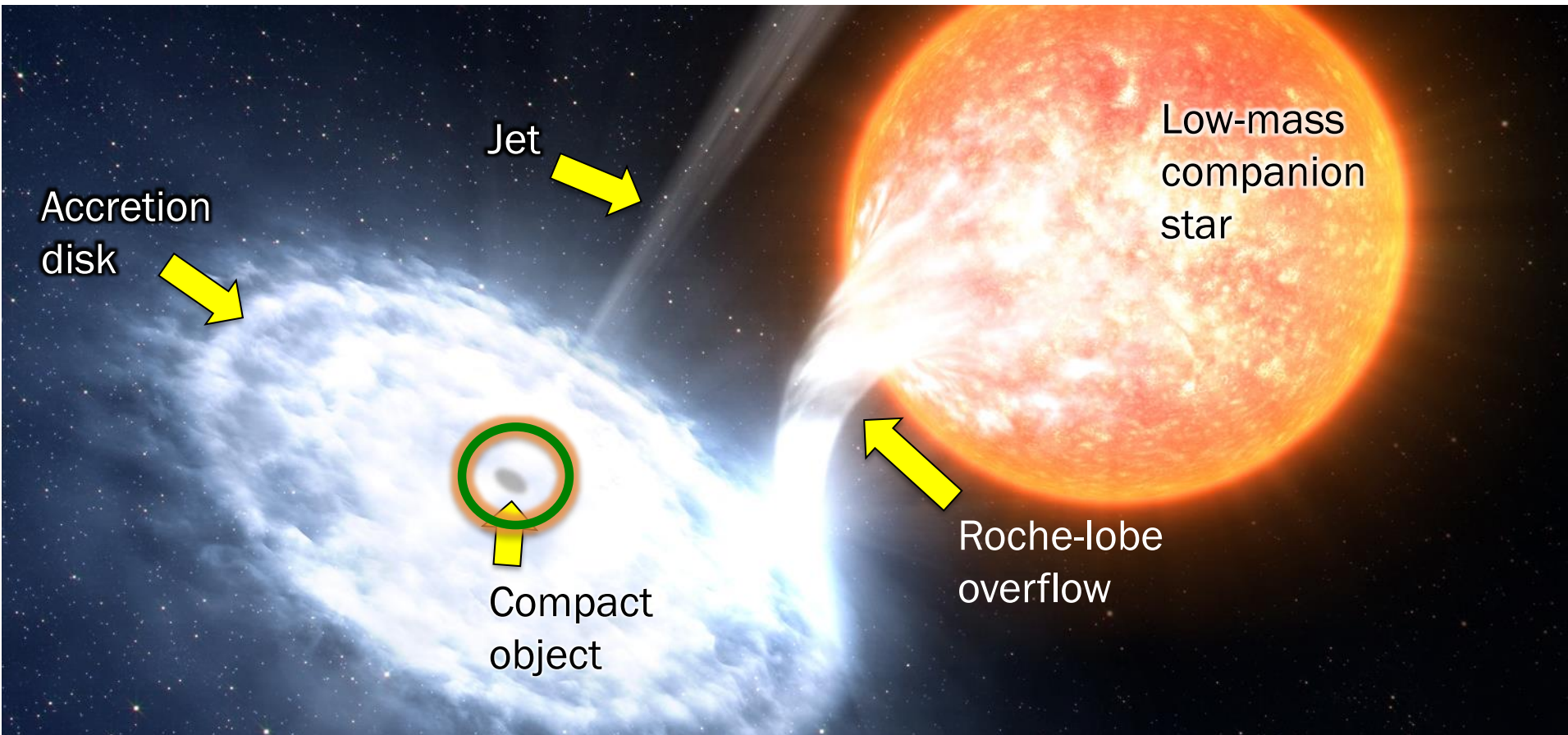
Abigail Stevens, Phil Uttley

University of Amsterdam

High-throughput X-ray astronomy in the eXTP era

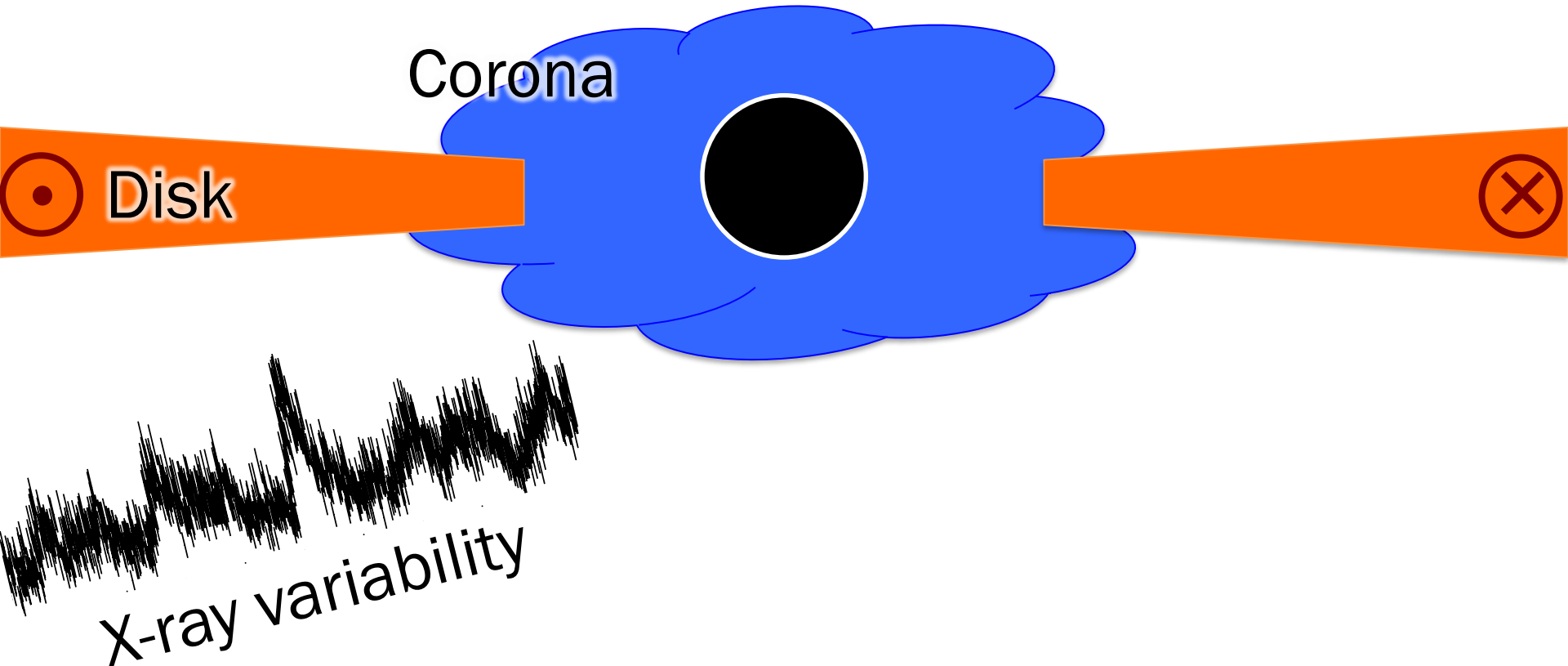


Low-mass X-ray binaries (LMXBs)

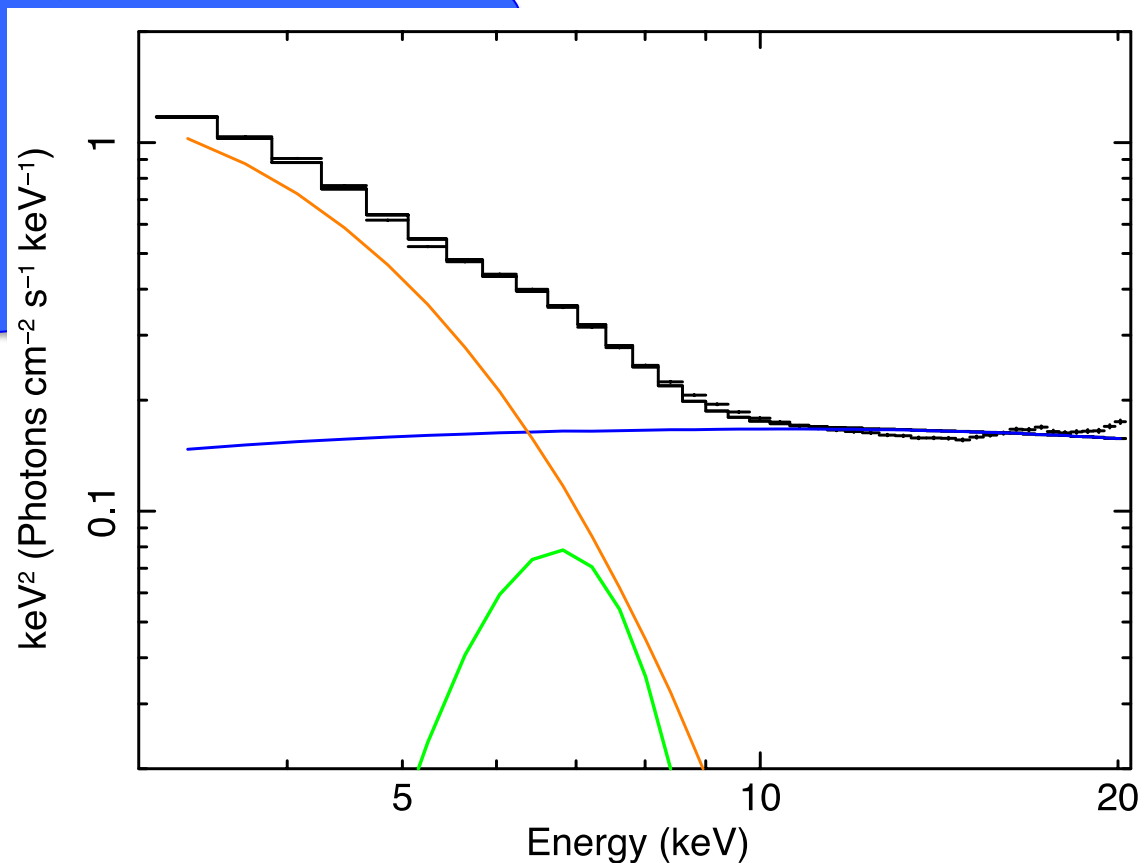
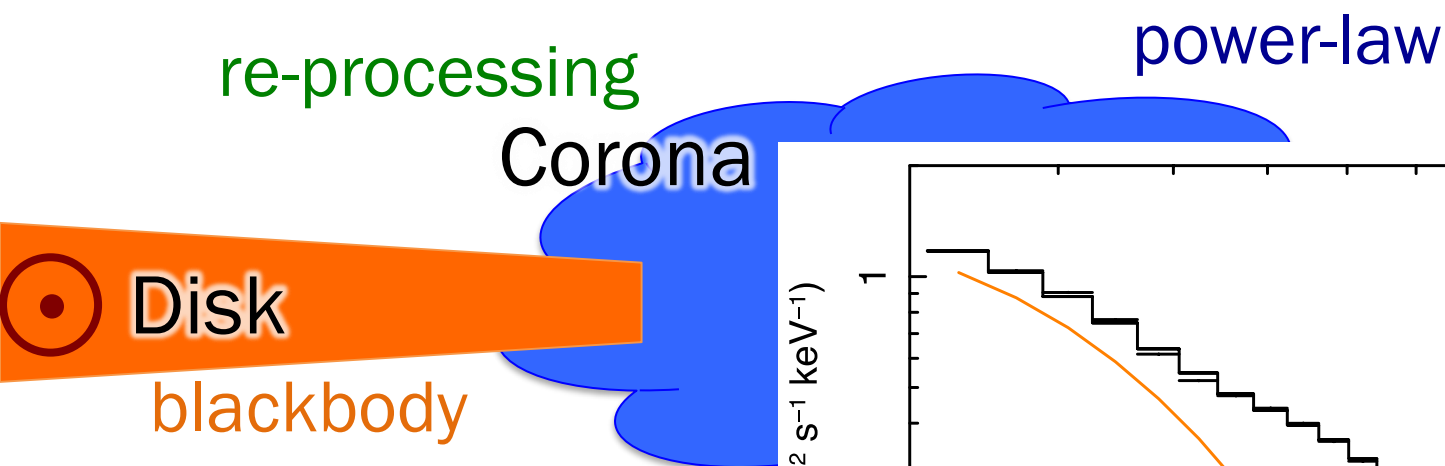


How does matter behave in strong gravitational fields?

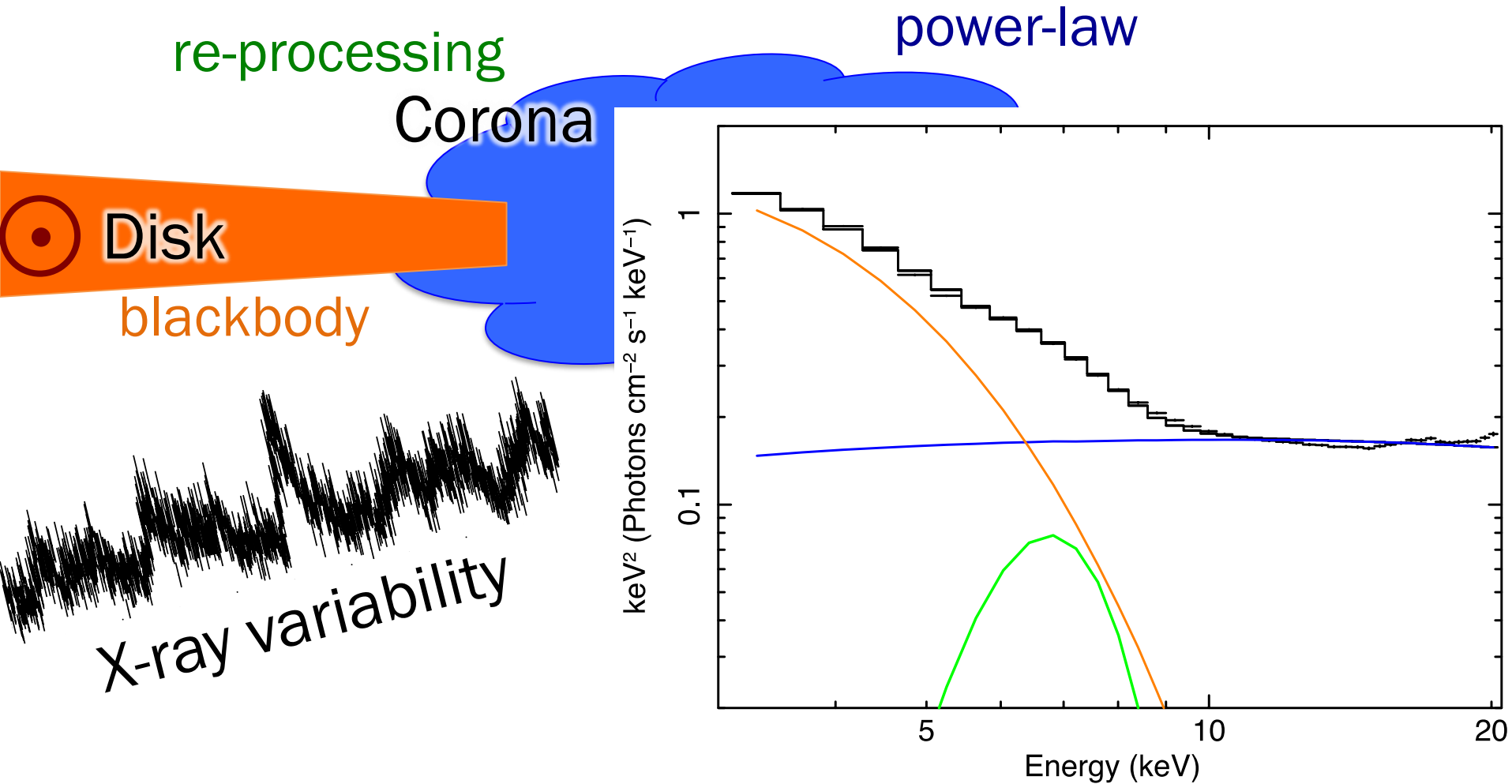
Inner region of an LMXB



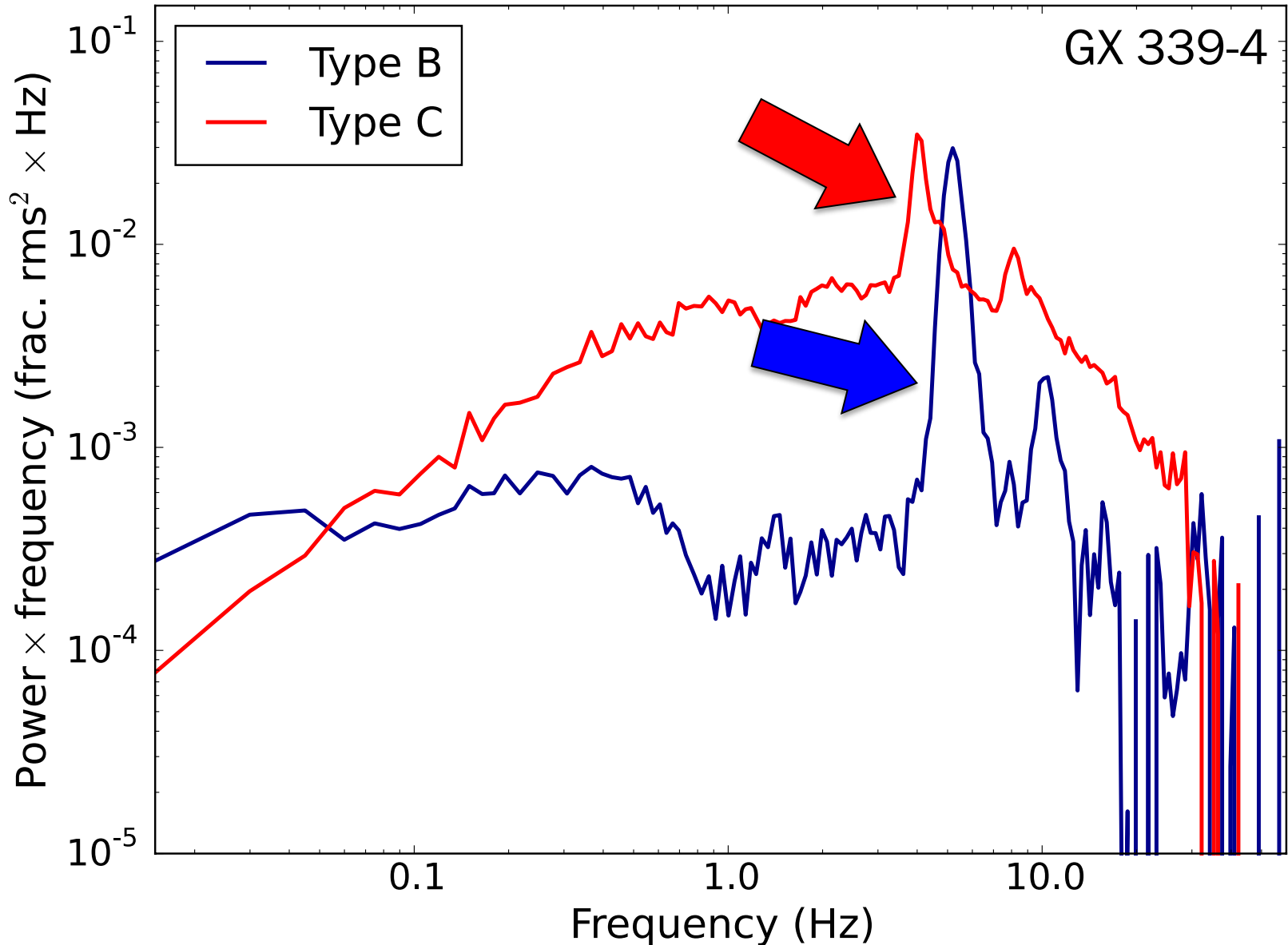
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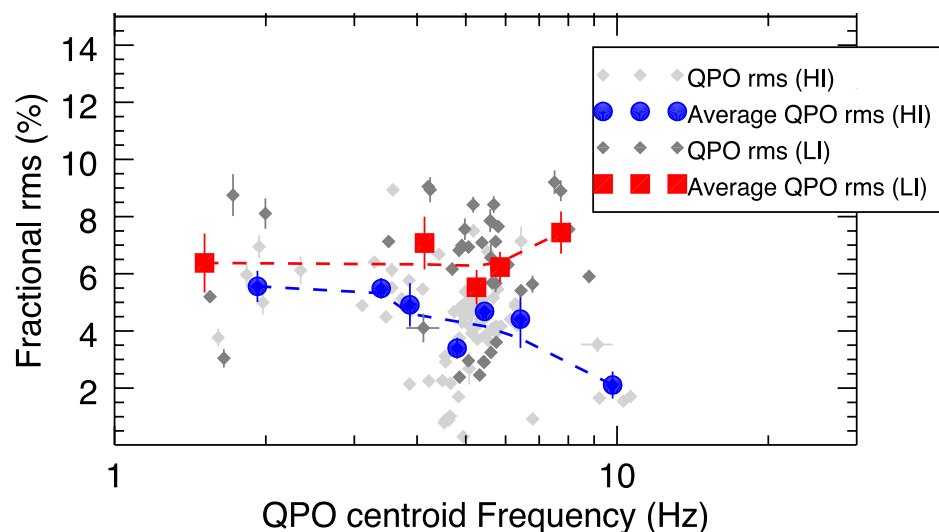


Quasi-periodic oscillations (QPOs)

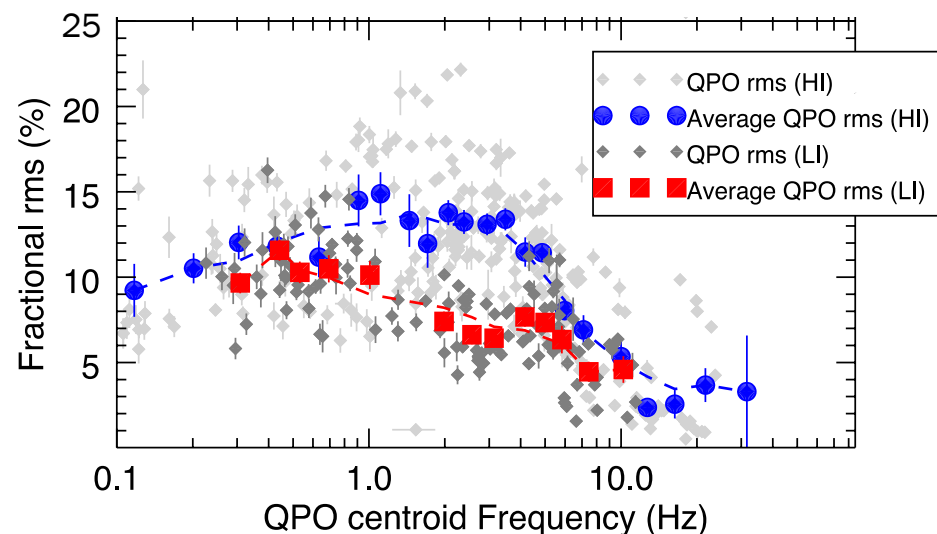


Binary inclination dependence

Type B's:
stronger face-on



Type C's:
stronger edge-on

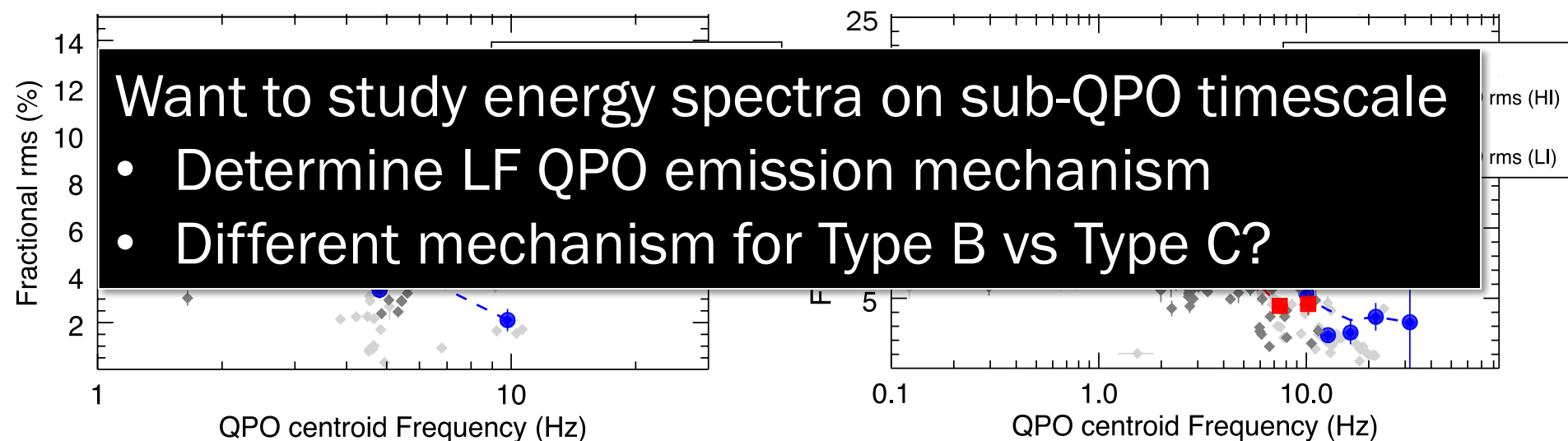


(binary system inclination)

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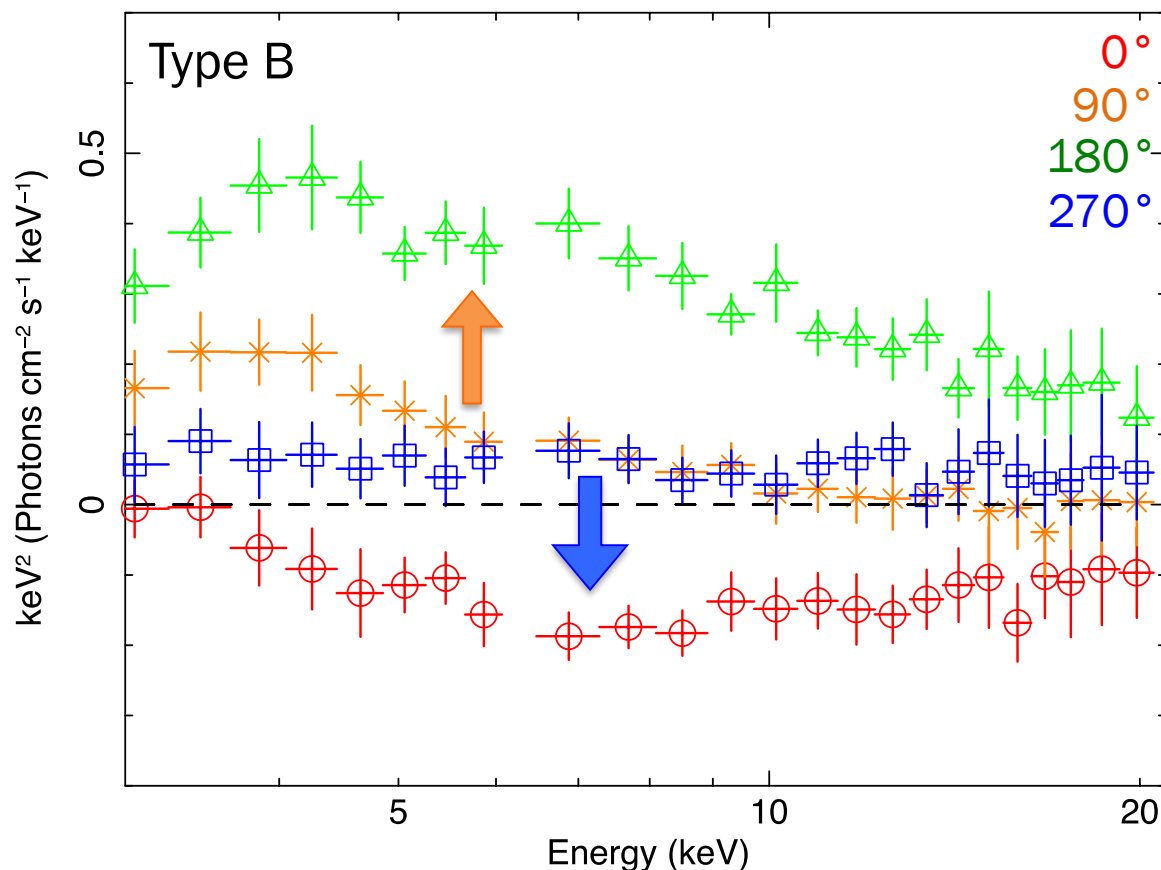
Phase-resolved spectroscopy

- New technique allows us to effectively do phase-resolved spectroscopy of QPOs
- Details in paper -- arXiv: 1605.01753

Phase-resolved spectroscopy

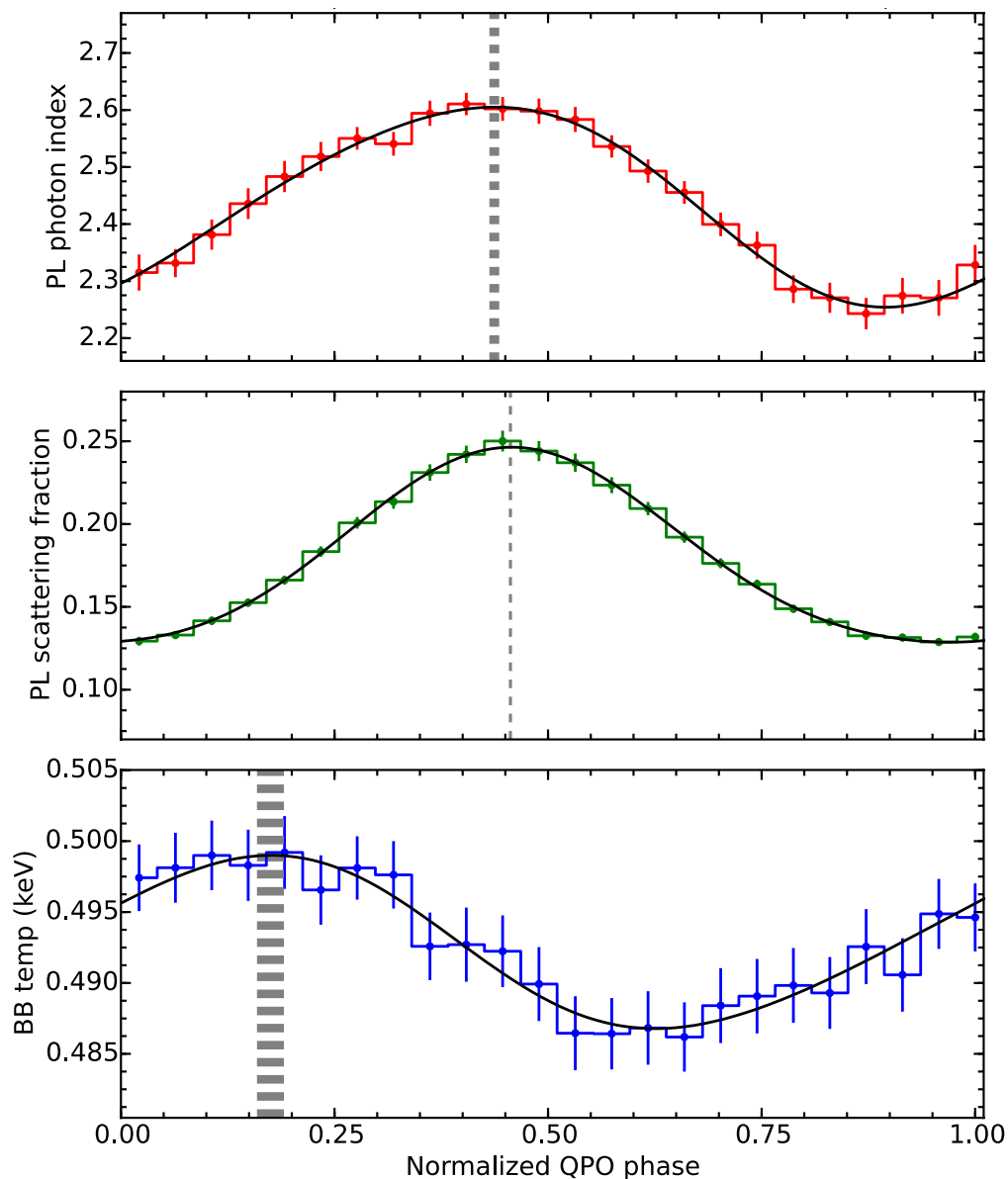
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- Deviations from mean energy spectrum
- Spectral shape varying with QPO phase!

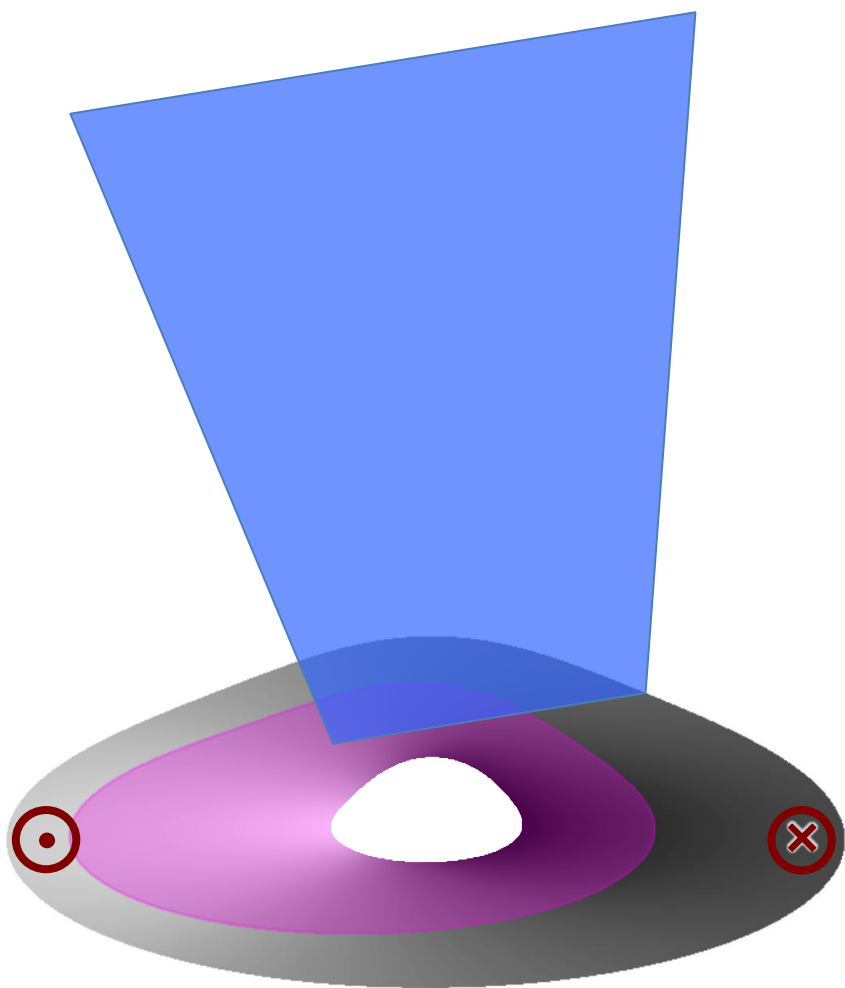


Type B QPO spectral variations

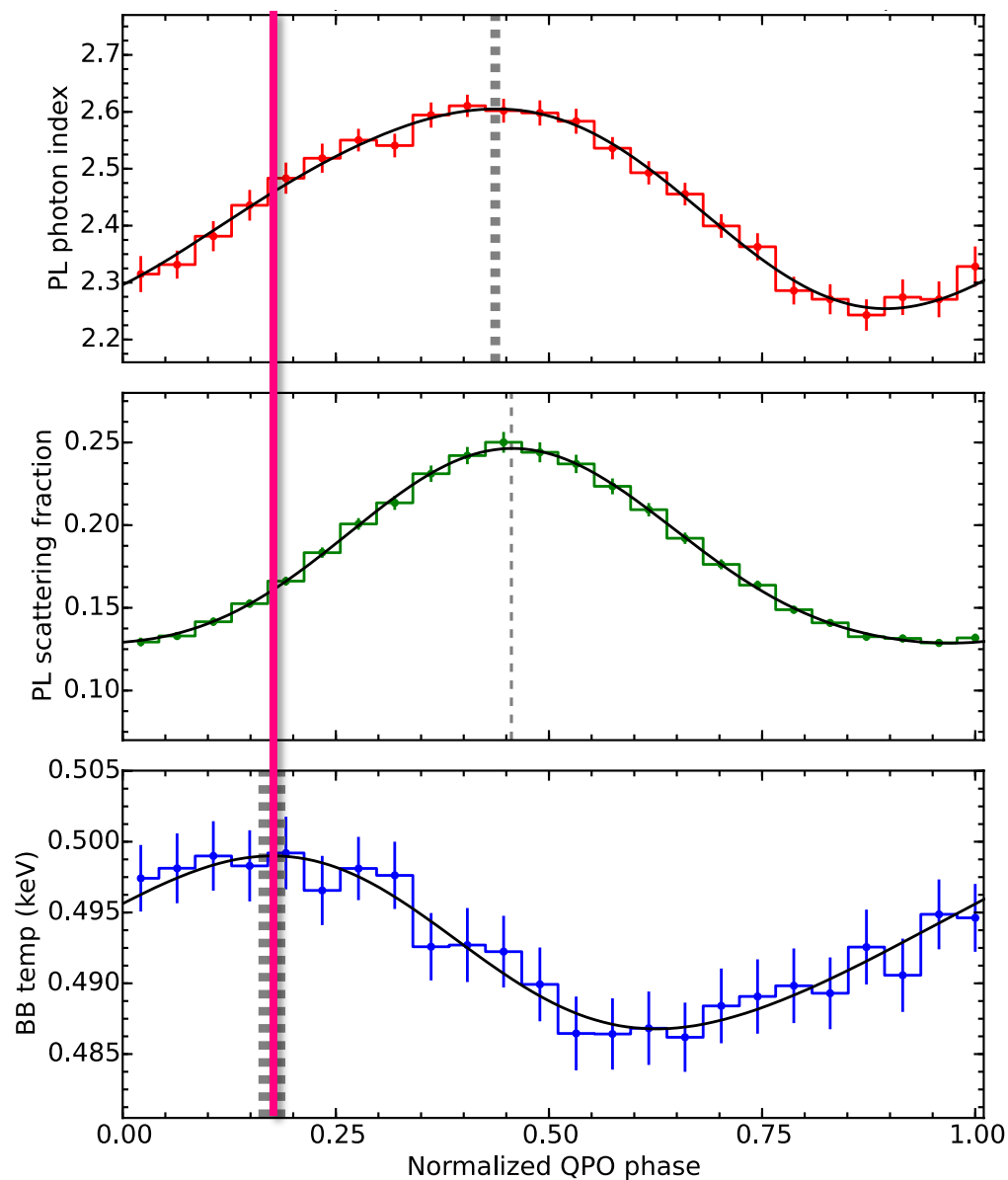
- Blackbody variation leads the power-law variation by ~ 0.3 (110°)
- Power-law: 25% rms variation
- Blackbody: 1.4% rms variation



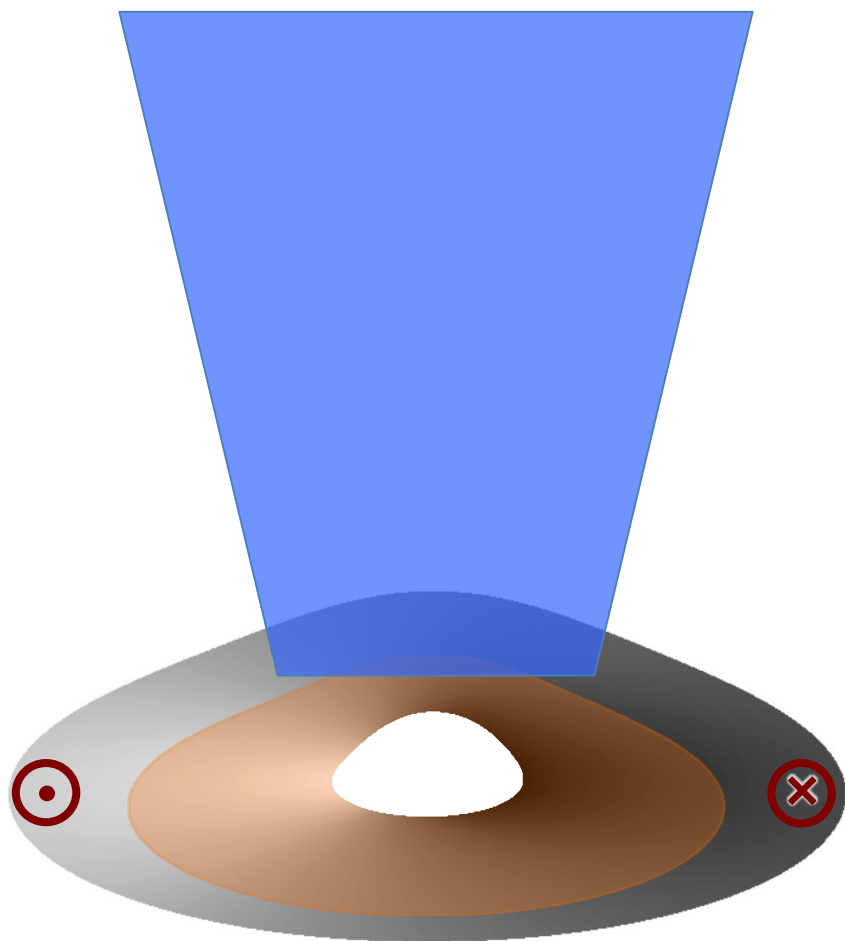
Type B QPO interpretation



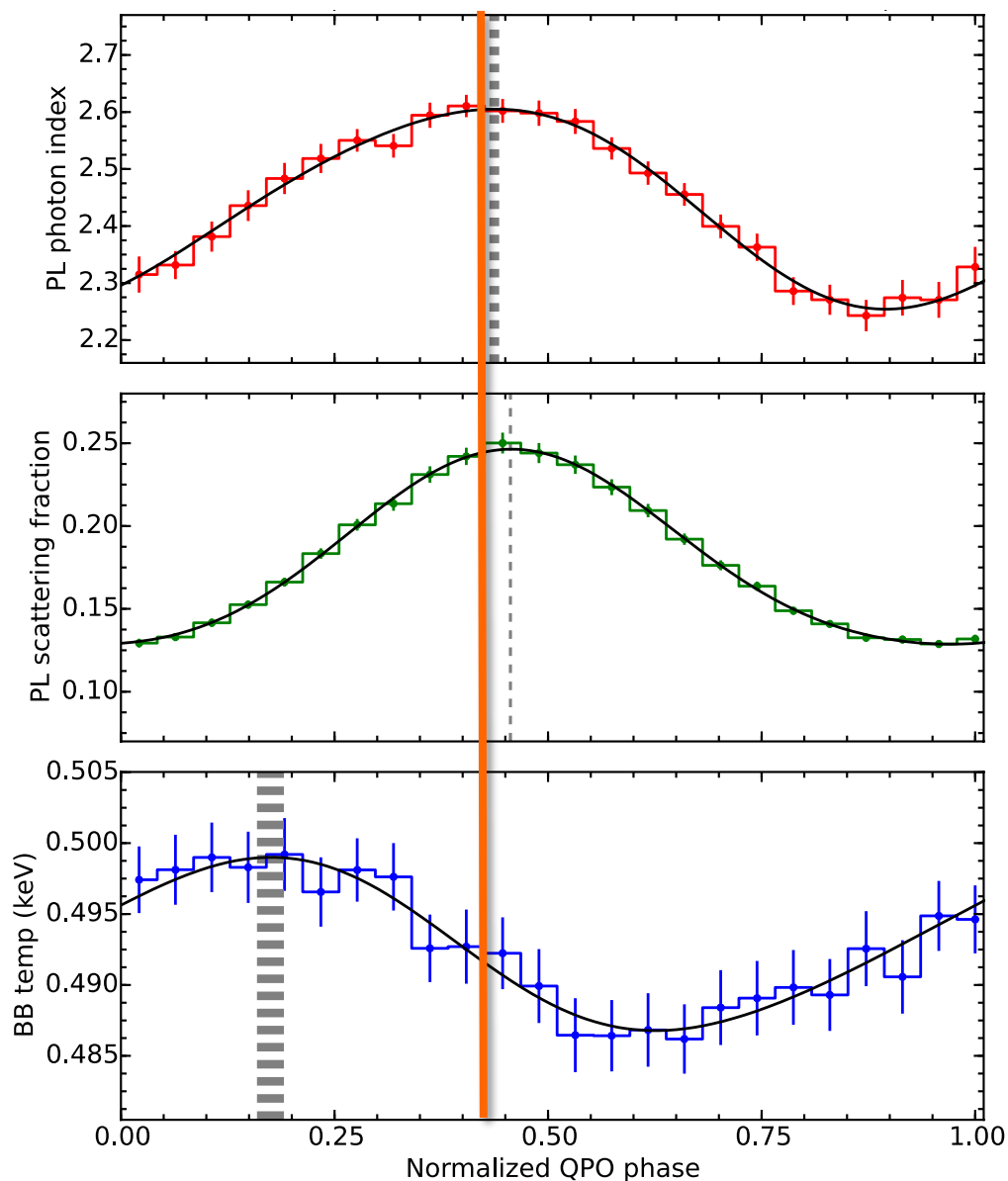
Large scale height, weakly modulated illumination



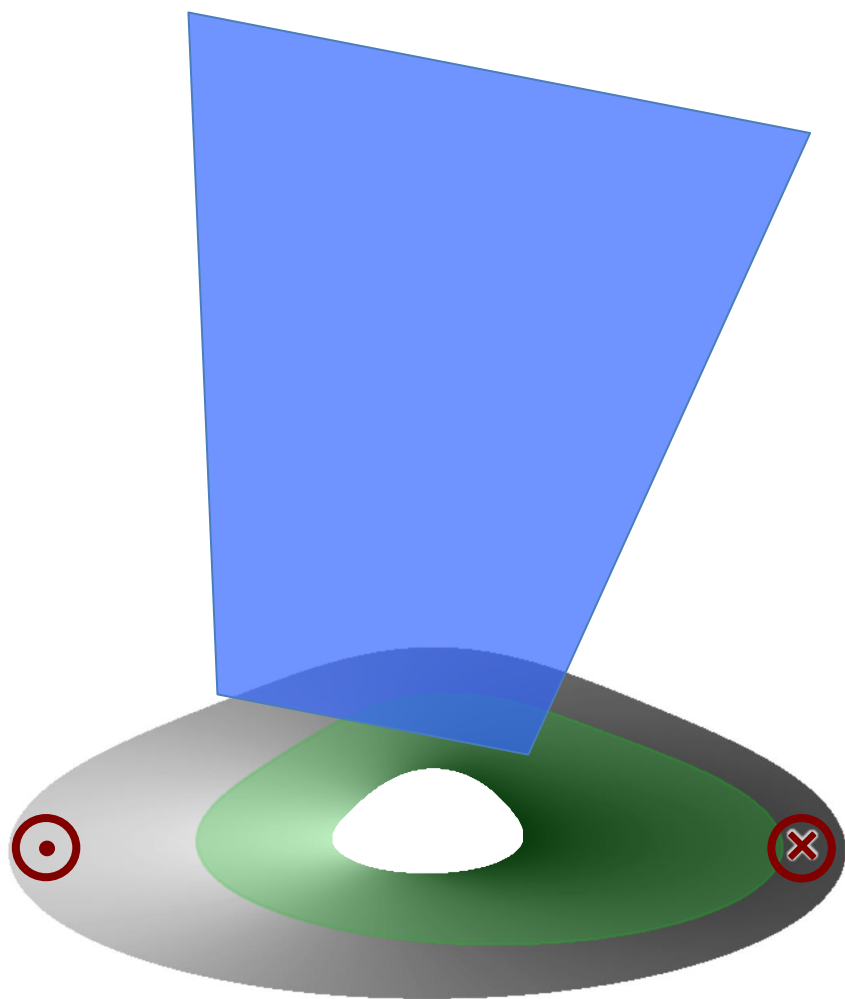
Type B QPO interpretation



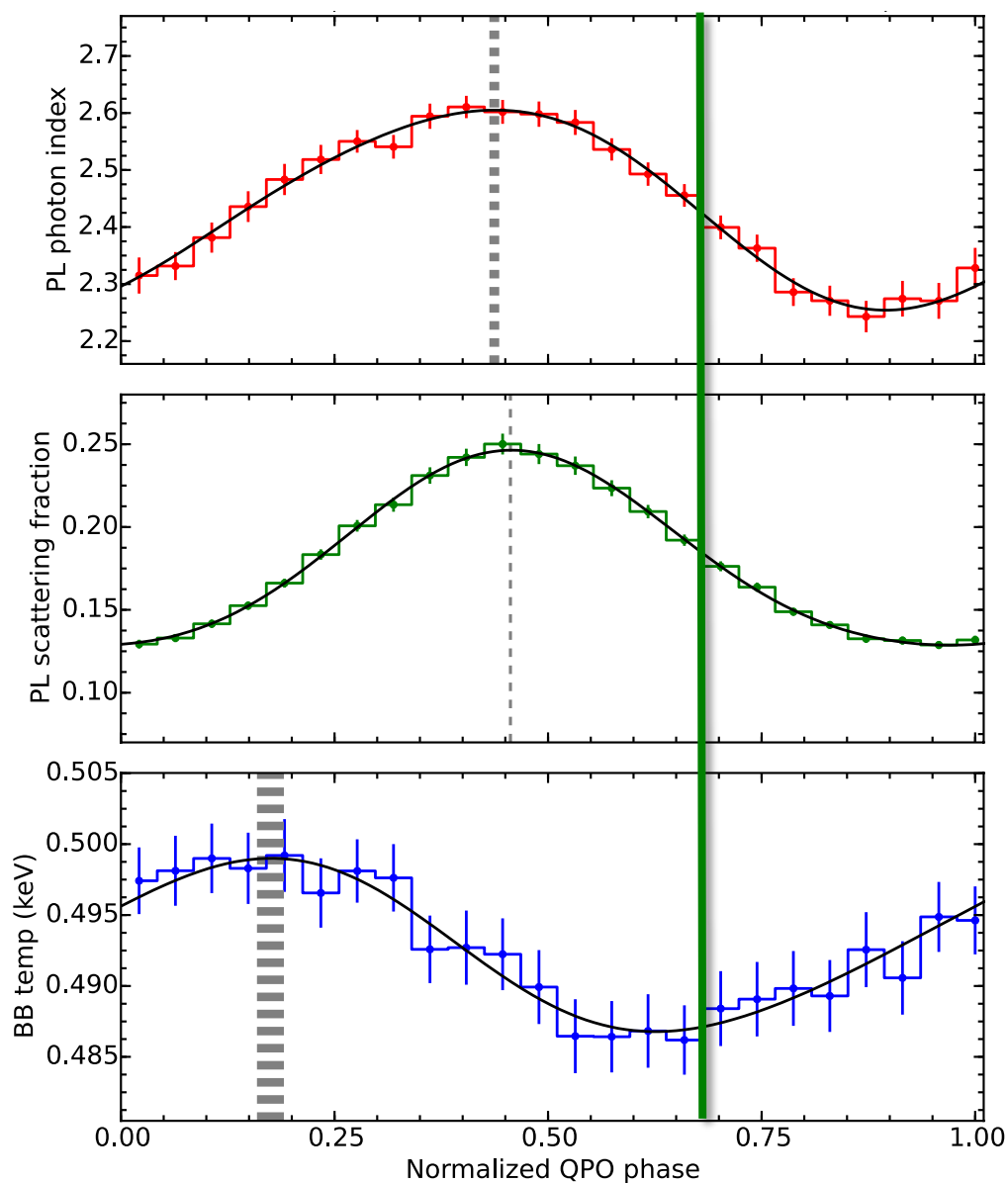
Large scale height, weakly modulated illumination



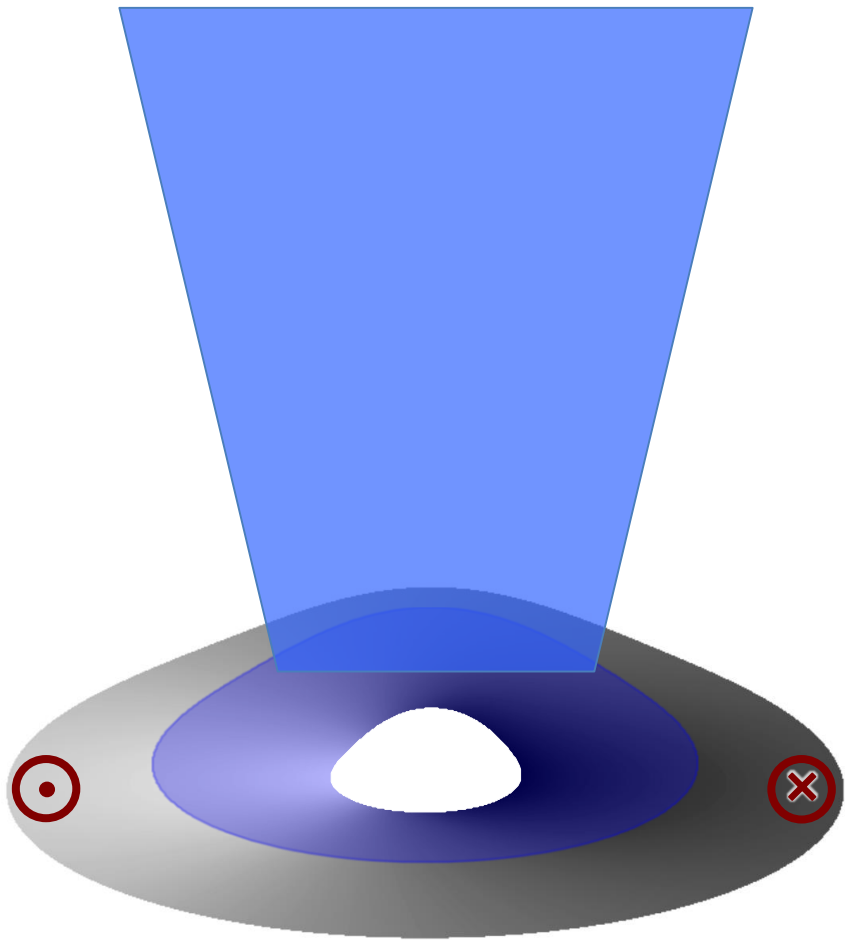
Type B QPO interpretation



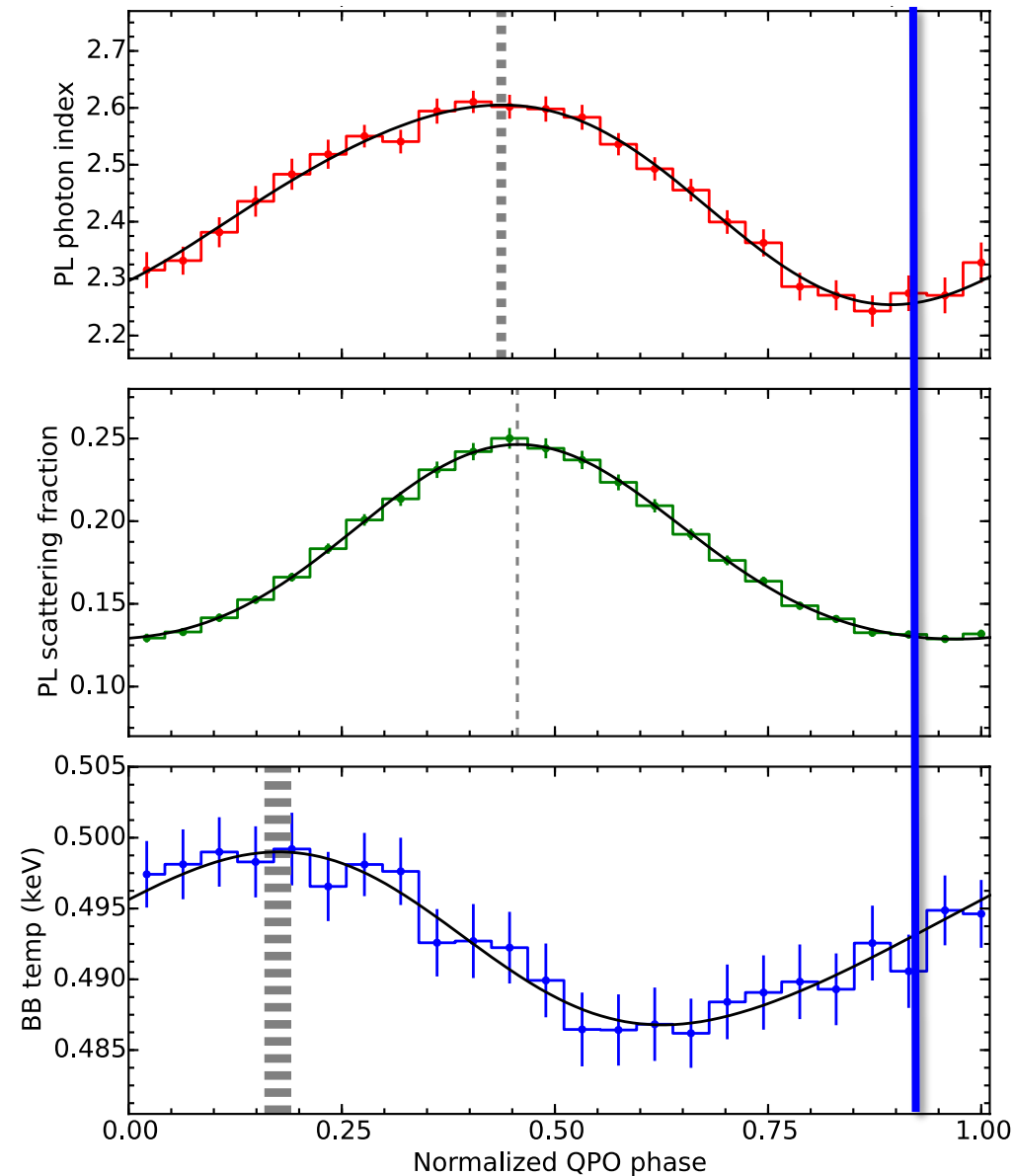
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Type B QPO interpretation

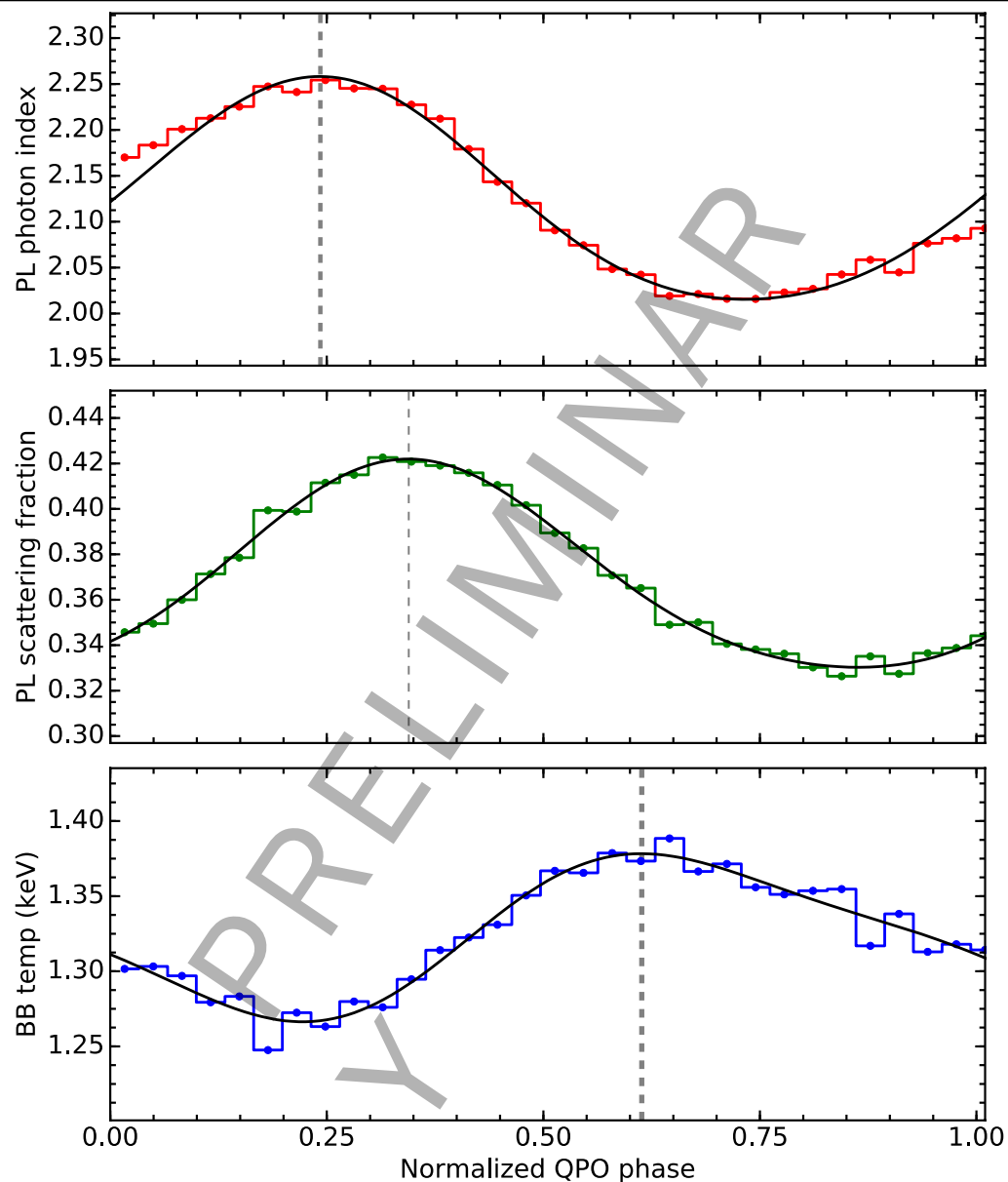


Large scale height, weakly
modulated illumination

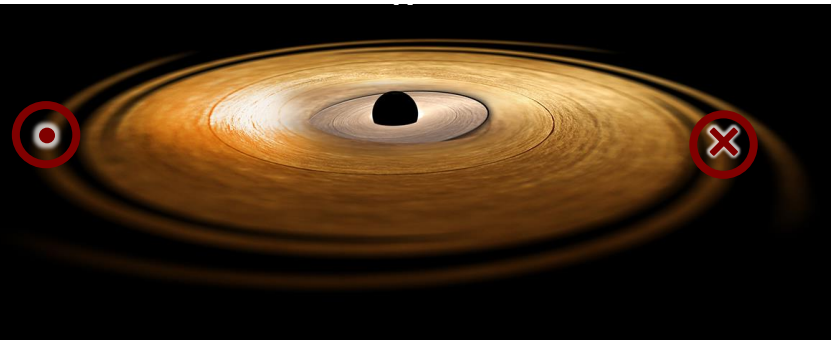


Type C QPO spectral variations

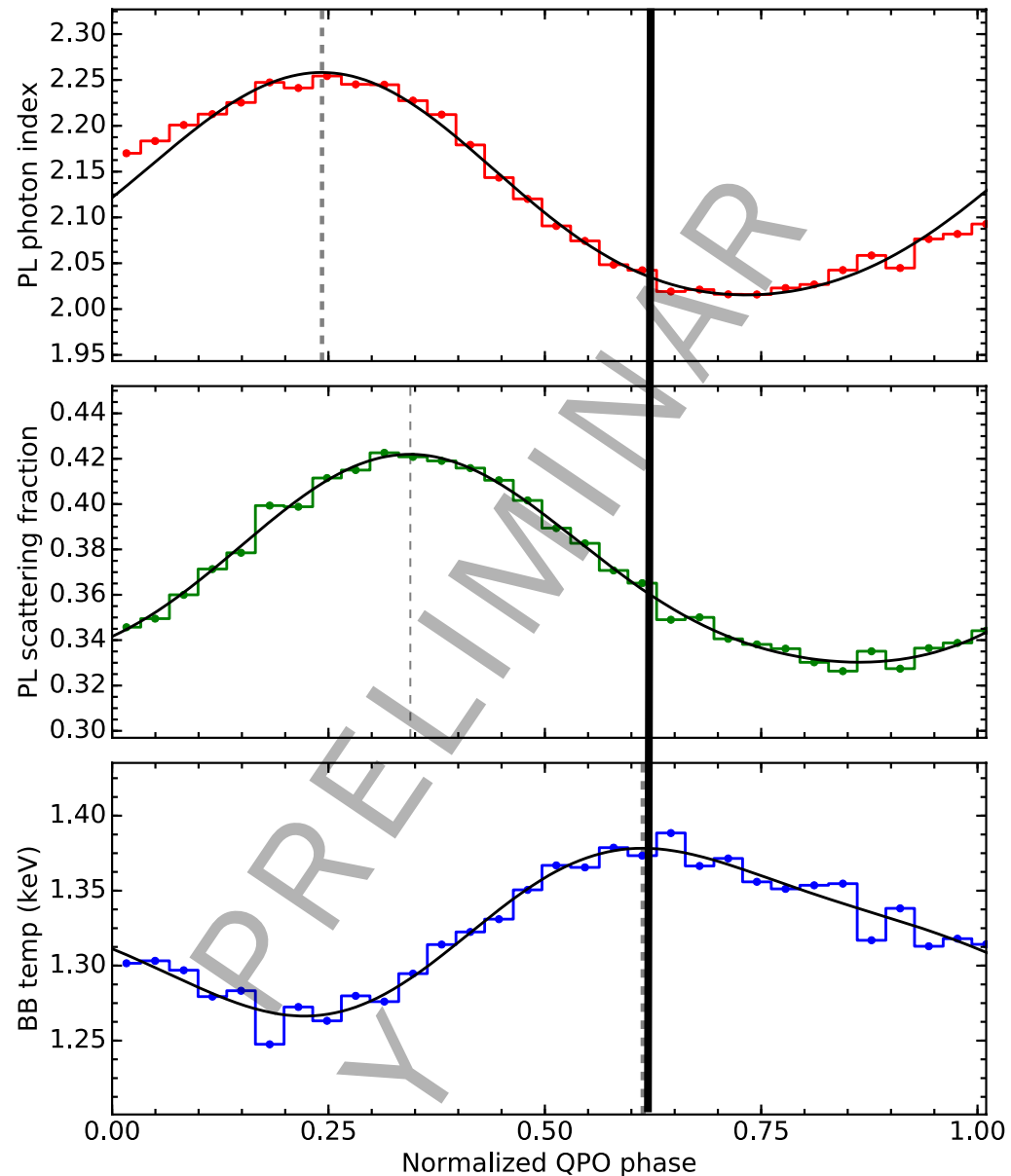
- Different parameter phase relationship
- Power-law: **smaller** variation (compared to Type B)
- Blackbody: **larger** variation



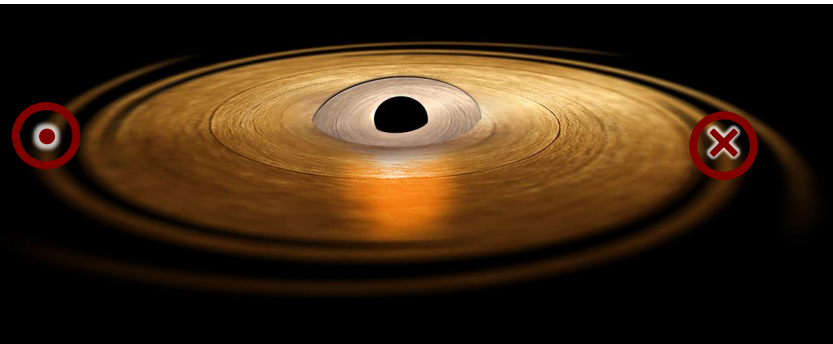
Type C QPO interpretation



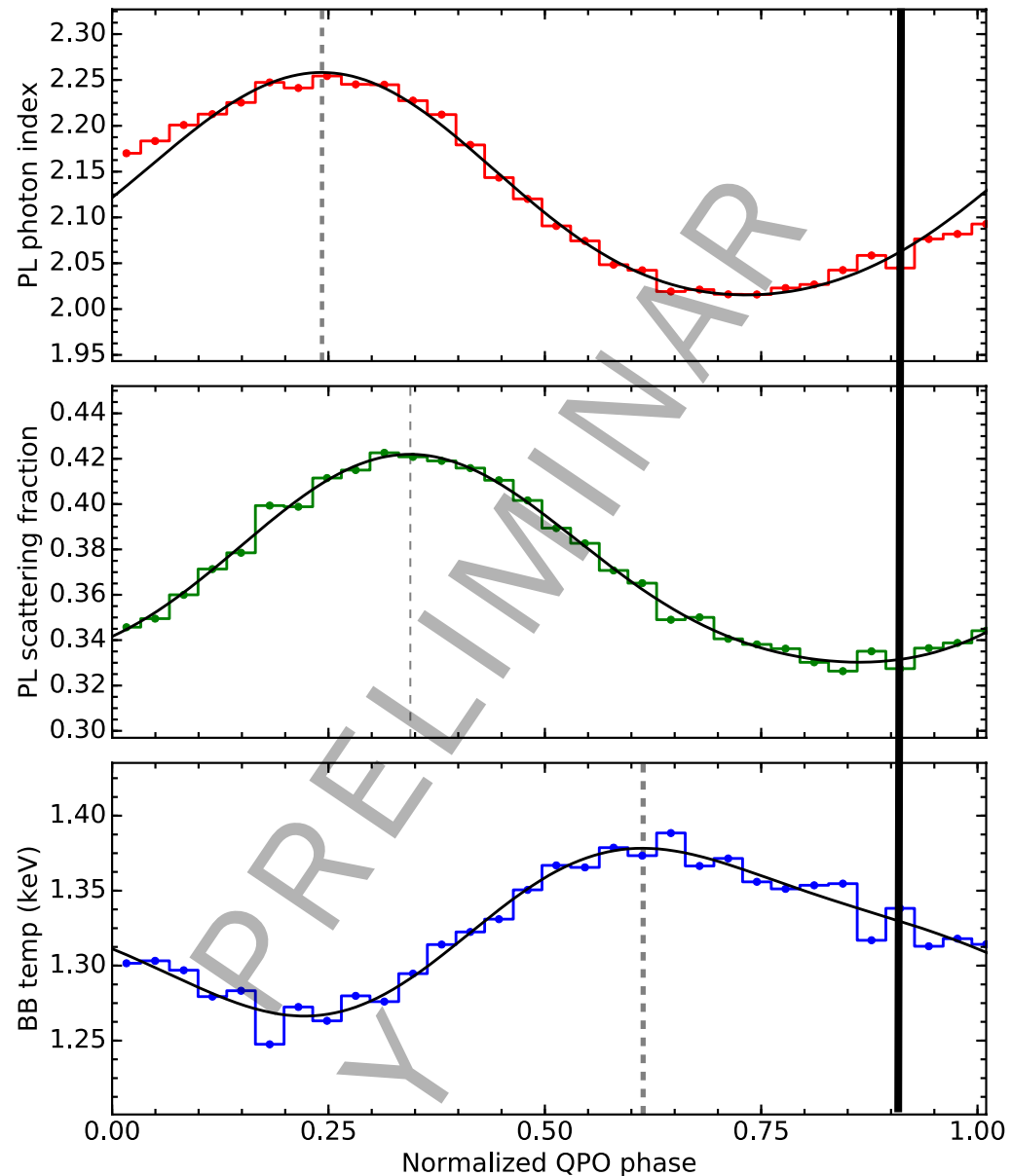
Small scale height,
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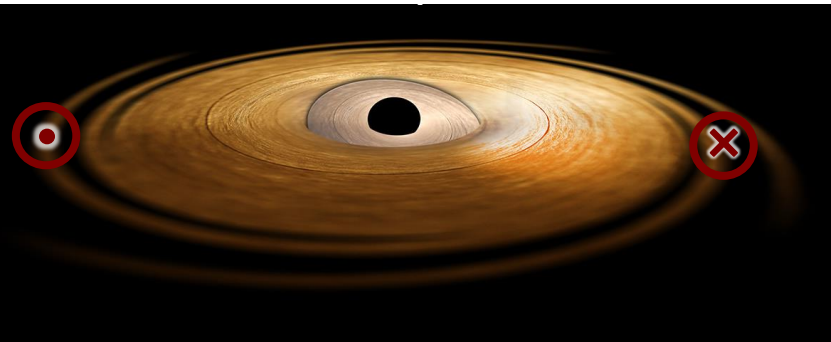
Type C QPO interpretation



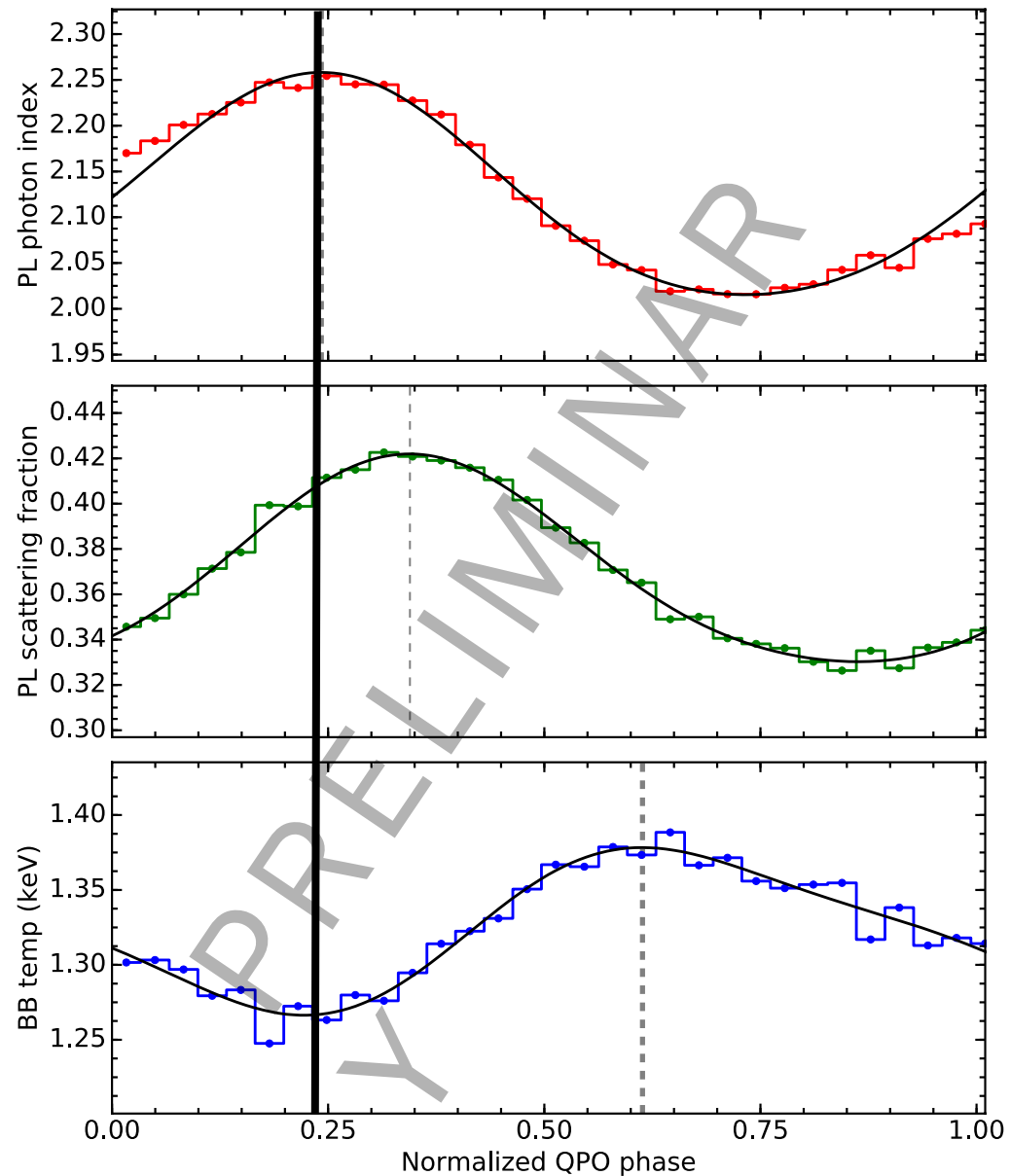
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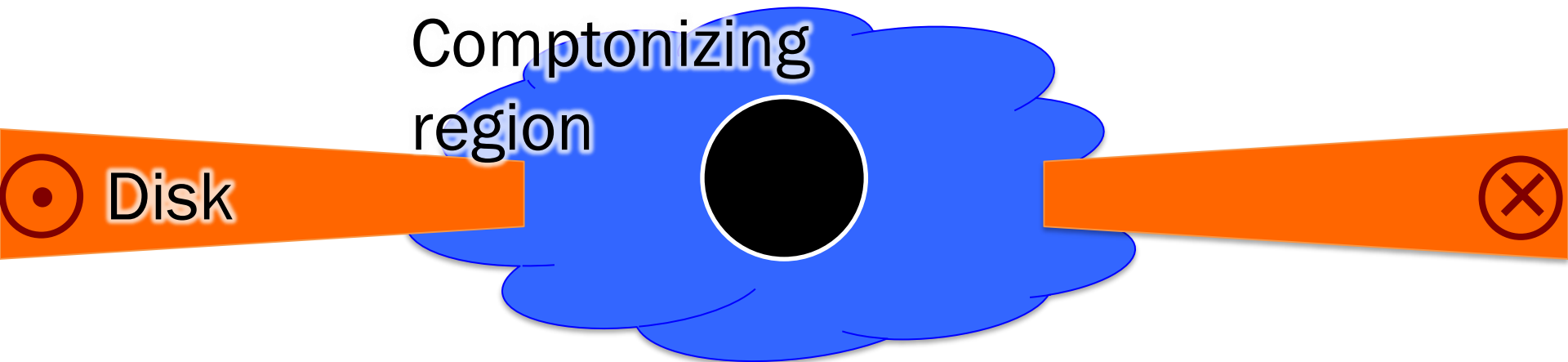
Type C QPO interpretation



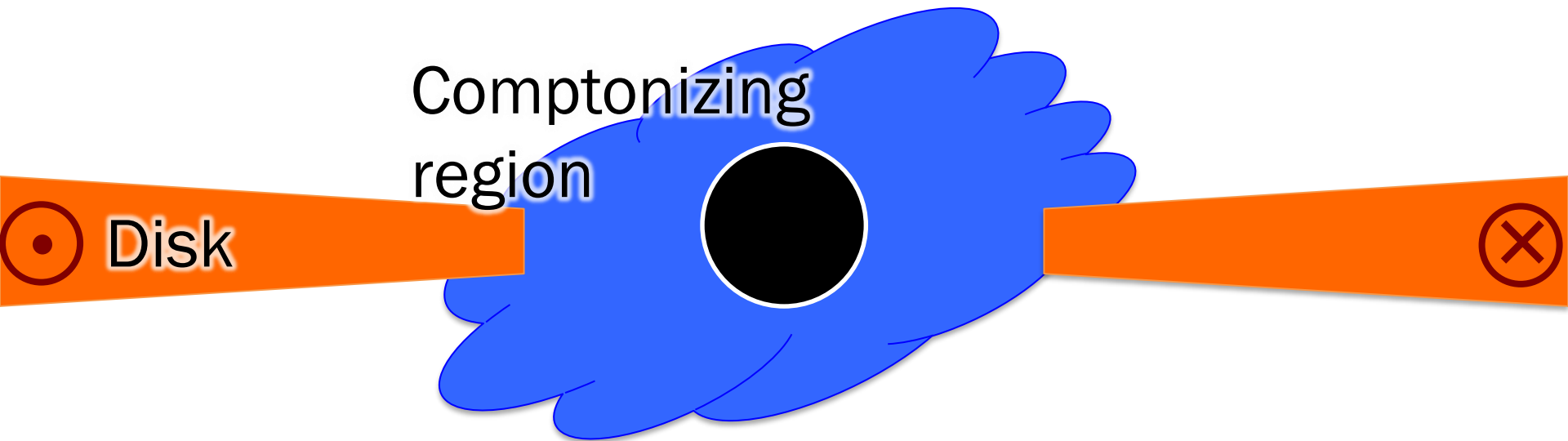
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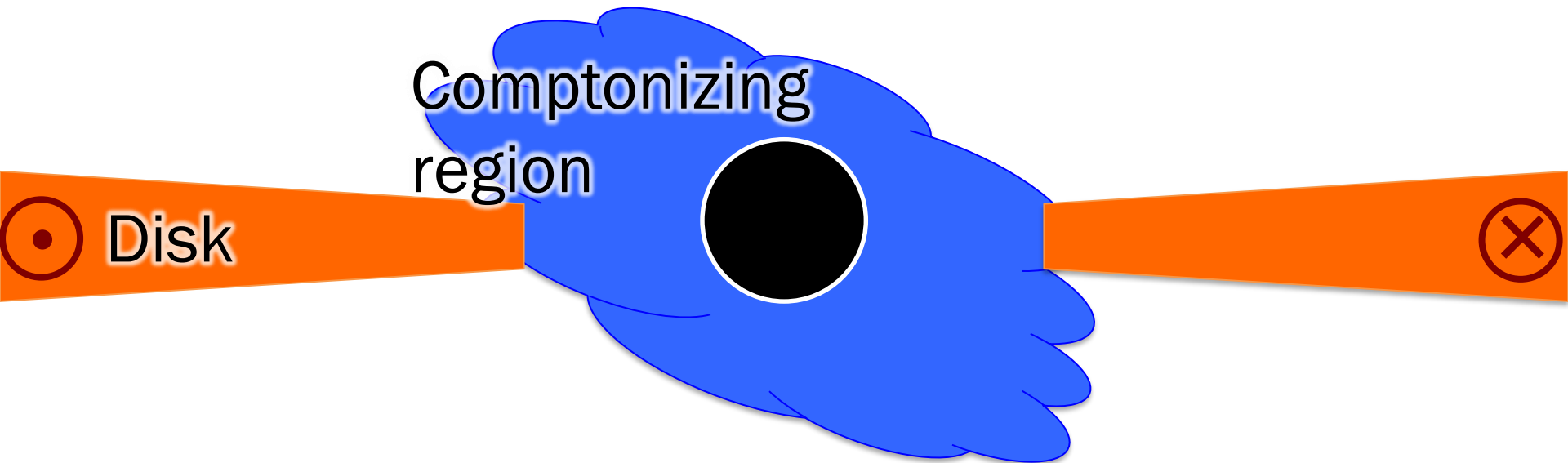


Lense-Thirring precession?



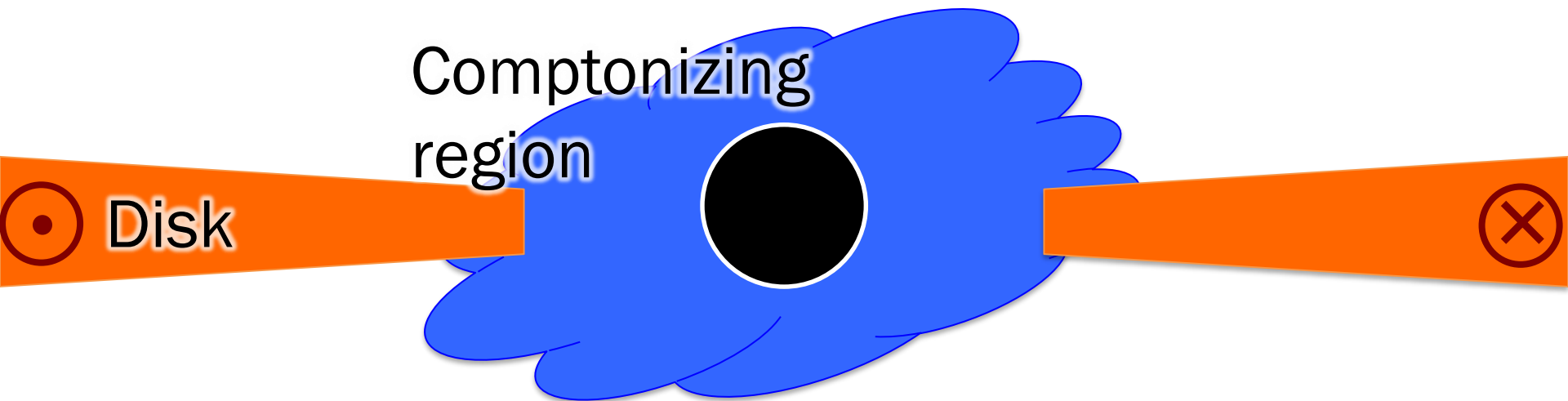
Stella & Vietri 1998; Fragile & Anninos 2005; Schnittman, Homan & Miller 2006;
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Ingram et al. 2016a,b

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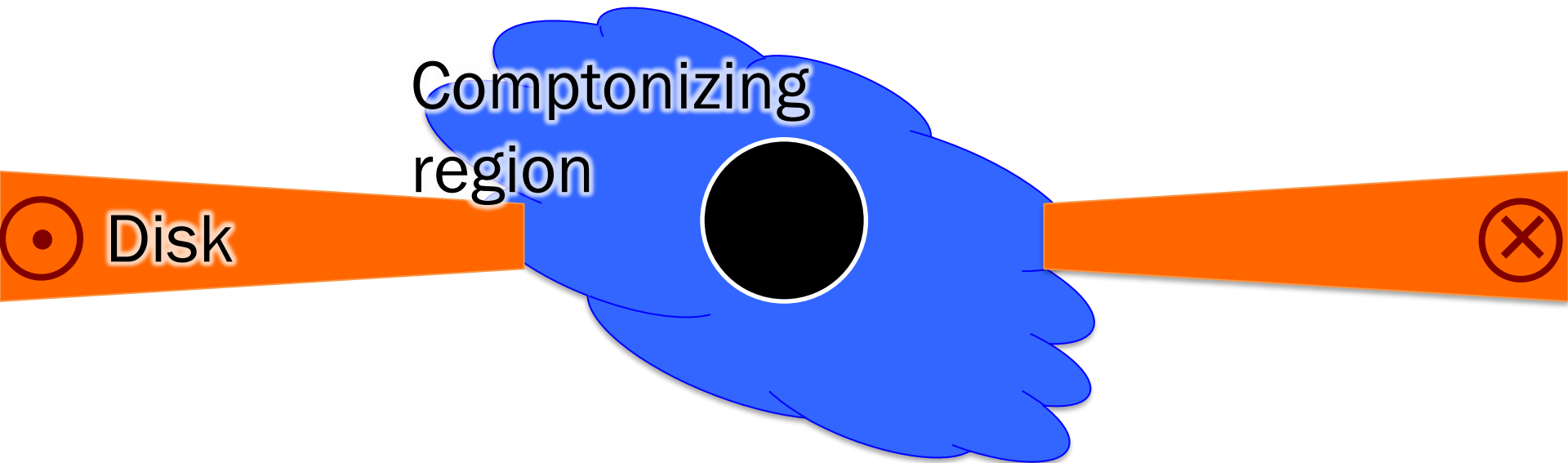
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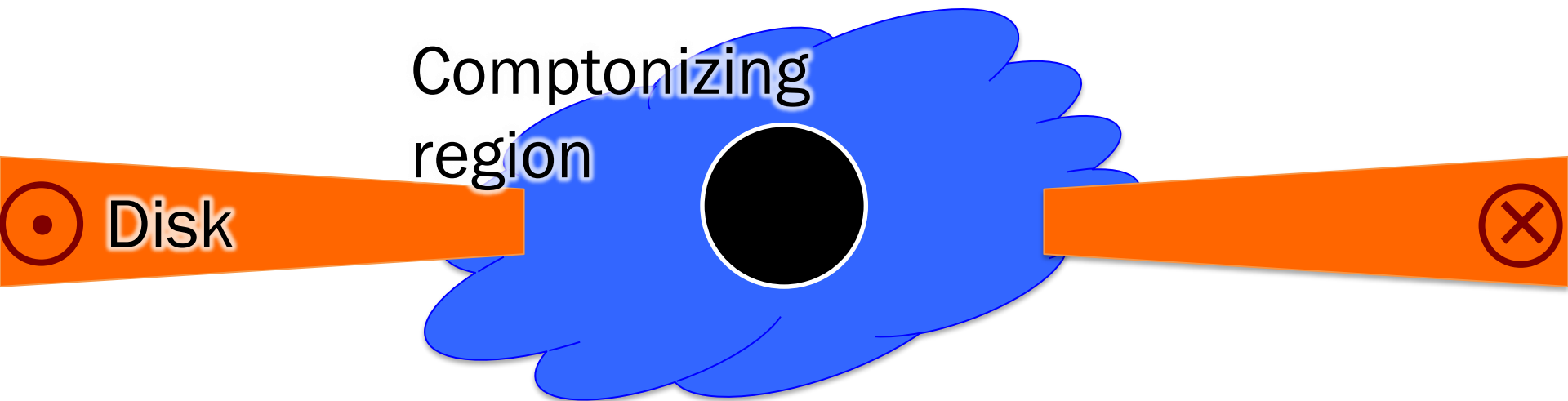
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- RXTE cannot sample peaks of blackbodies
- Which blackbody varies?
- Further complications for NSs

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Solve with eXTP SFA (0.5-20 keV):

- Simulations with 13ks (assuming no bkgd)
- Easily differentiate between variable blackbody models (χ^2 differ by orders of magnitude)

- X-ray low-frequency QPOs come from inner region of X-ray binaries
- Phase-resolved spectroscopy of QPOs, **especially using eXTP**, can break degeneracies between physical models
- Type **B** QPO in GX 339—4:
 - **Jet**-like precessing region
 - arXiv: 1605.01753
- Type **C** QPO in GX 339—4:
 - **Disk**-like precessing region
 - Paper in prep.



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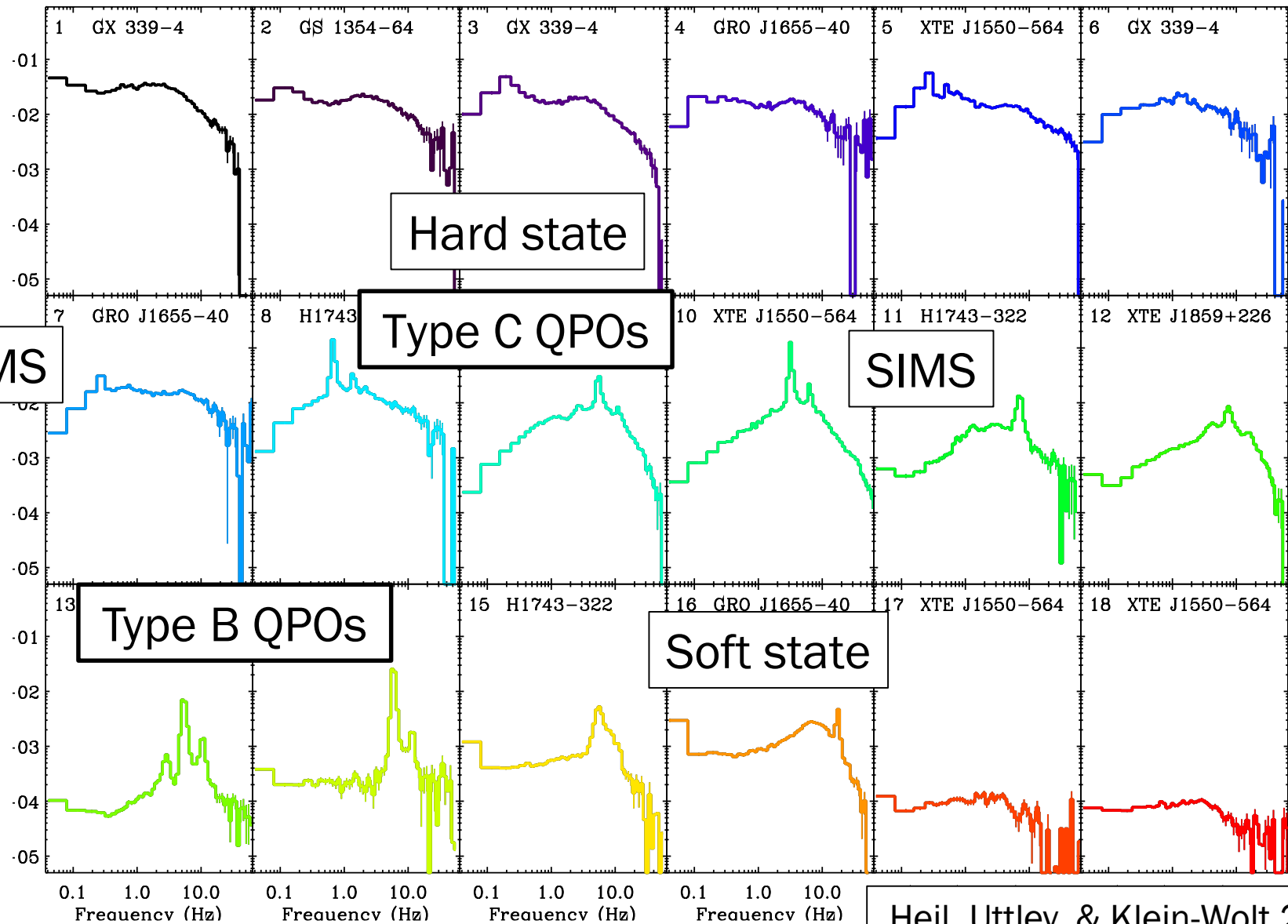


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BH QPOs and Spectral States



Comparing Lag-Energy Spectra

