

Effects of geometry and mass accretion rate on thermal spectra of ULX sources

Michal Bursa

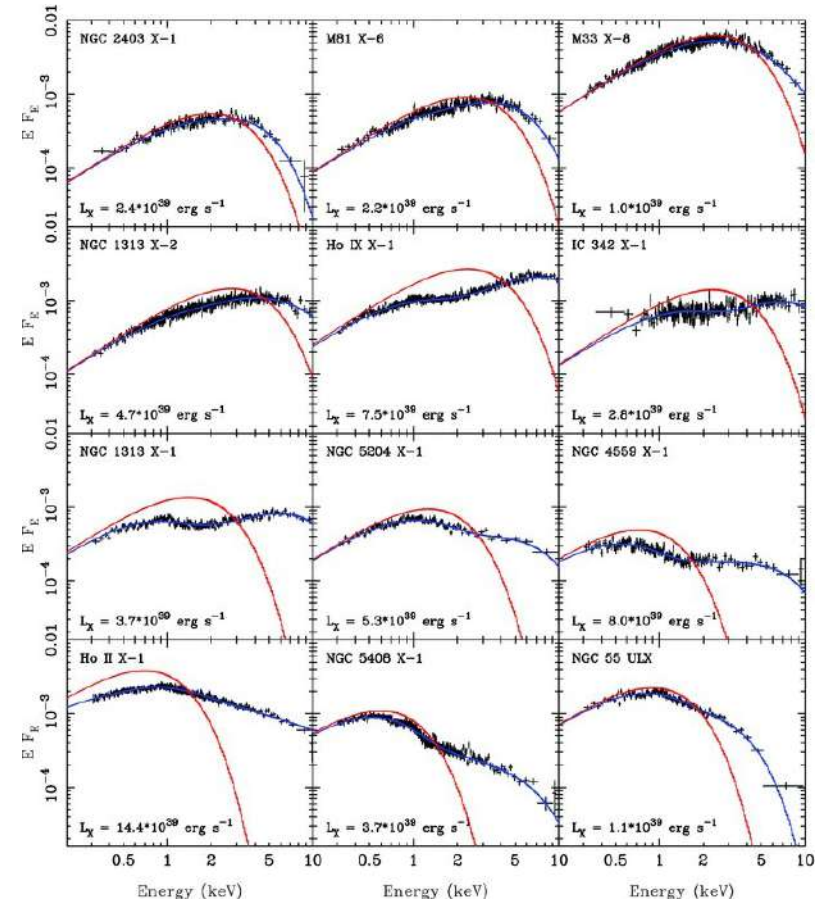


Motivation

Spectral modeling of ULXs:

- most often a model with disk+pl or disk+th_comp is used
- in place of a disk model we can see DISKBB, DISKPN, KERRBB, BHSPEC, GRAD, etc
- all of the listed disk models are based on thin disk model, which is inaccurate for $L > 0.3 L_{\text{Edd}}$
- BUT, such a modelling tends to give incorrect values for BH masses and for accretion rate (luminosity)
- **how much wrong?**

(Gladstone et al. 2009)

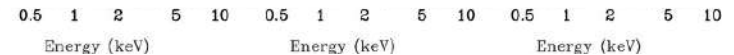
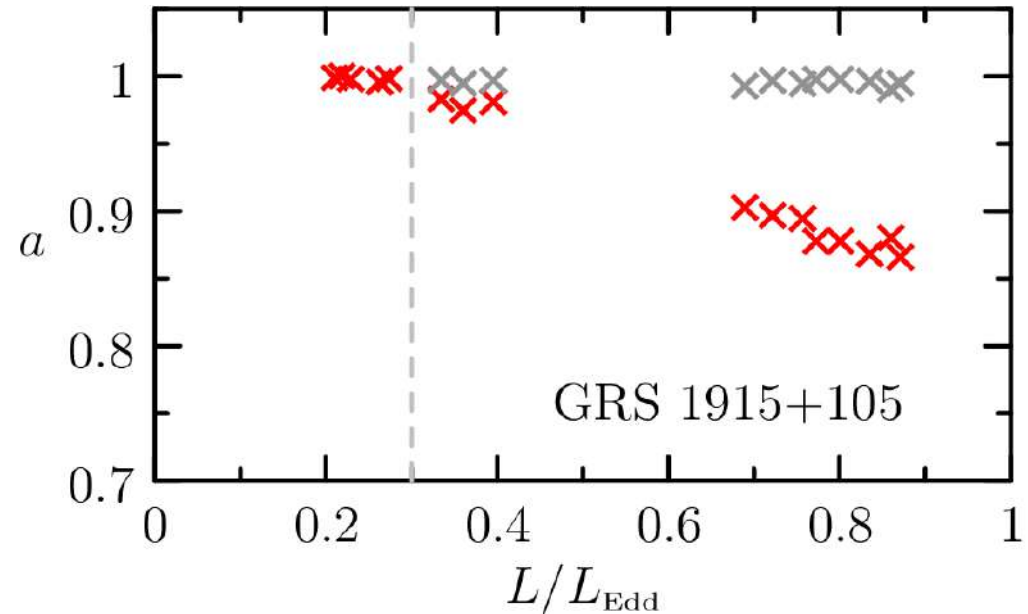
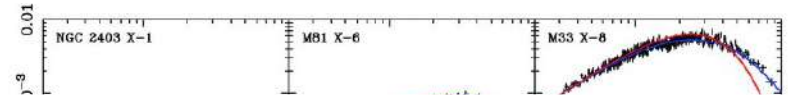


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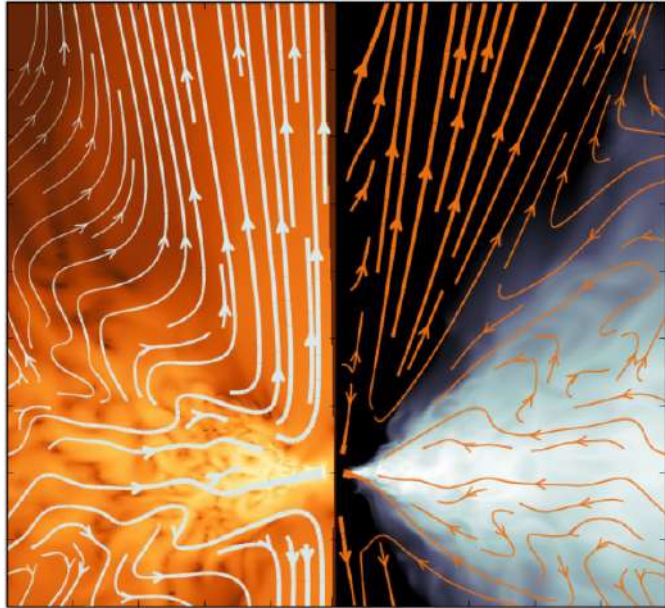
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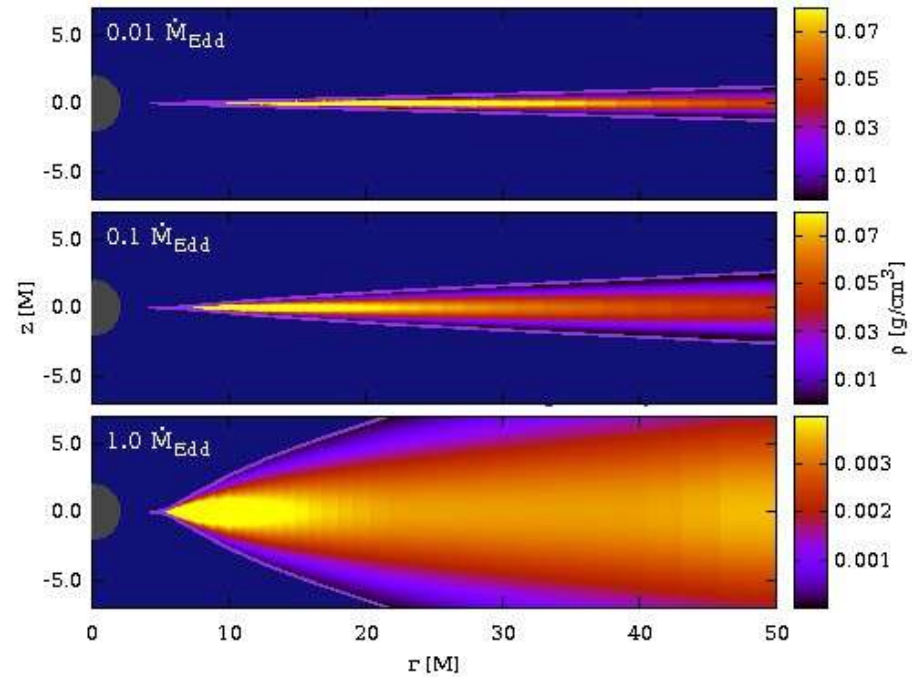
Spectral model based on slim disk model

Numerical simulations



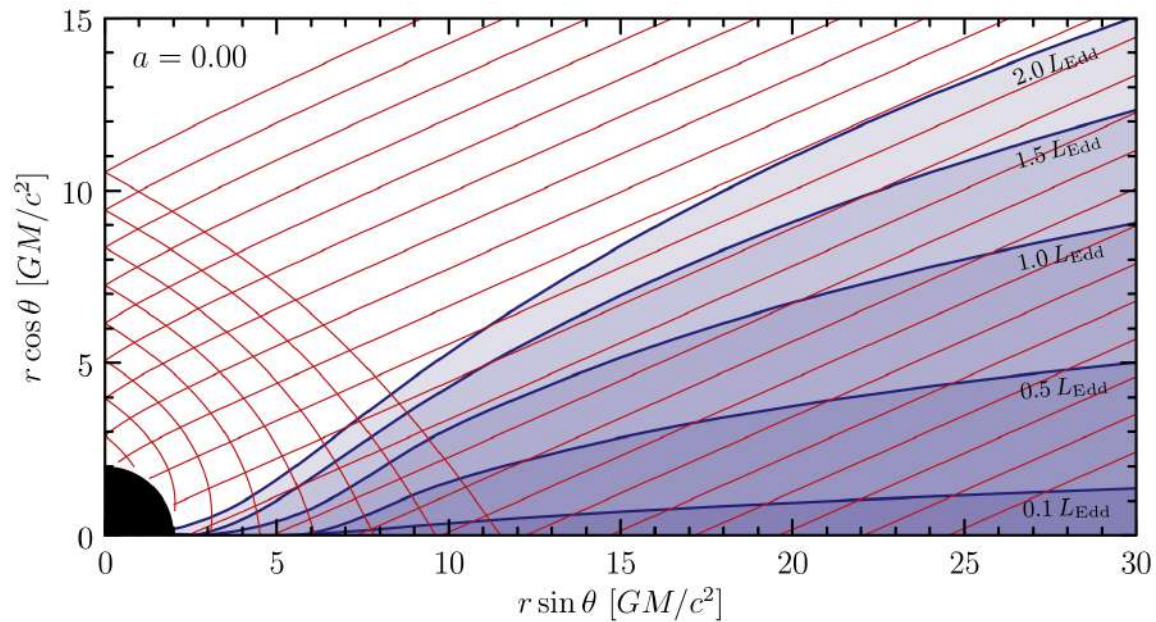
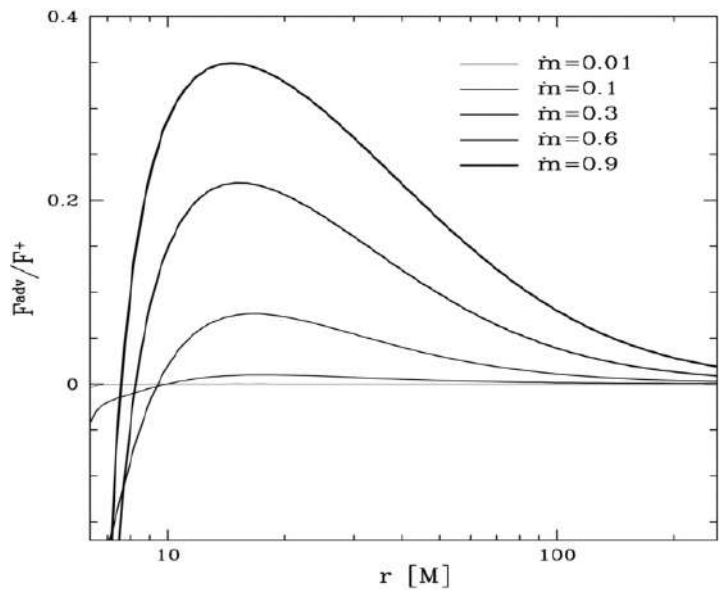
Credit: A. Sadowski

Analytical solutions



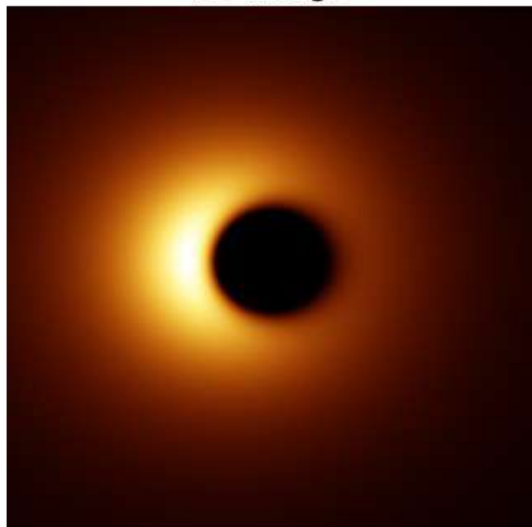
Sadowski+2009

Spectral softening: advection & geometry

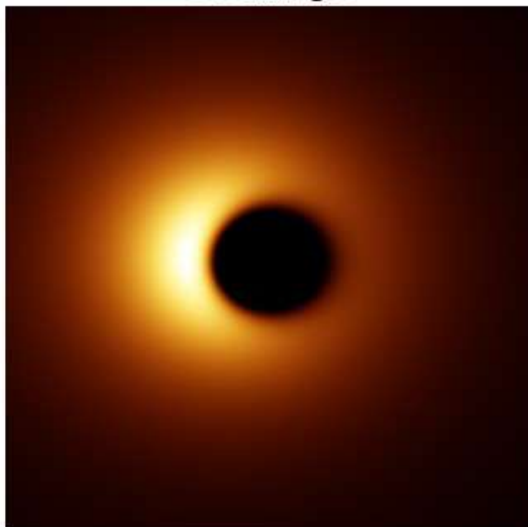


ULX spectra ($a=0.00$, $i=30^\circ$)

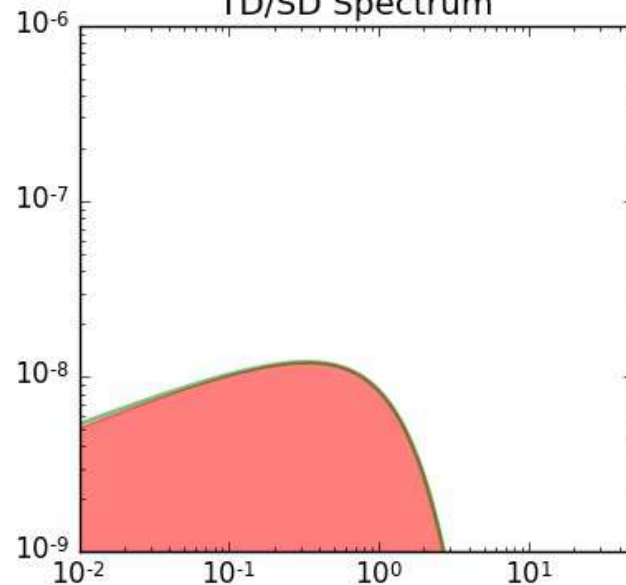
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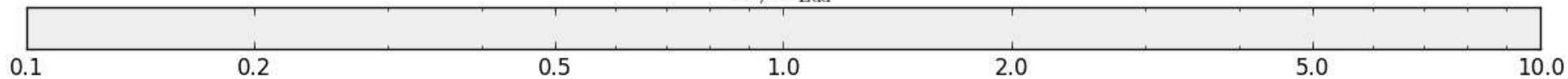
SD image



TD/SD Spectrum

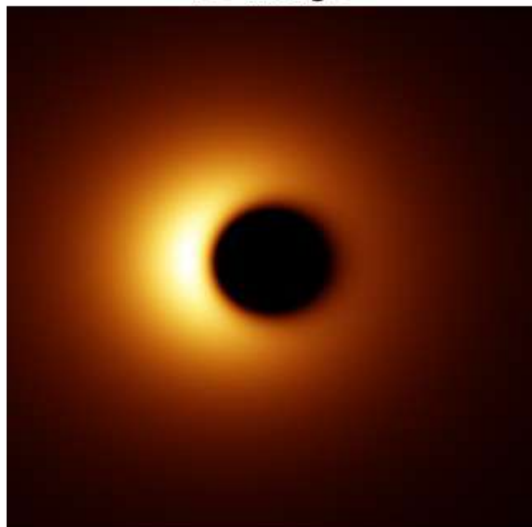


$\dot{M}/\dot{M}_{\text{Edd}}$

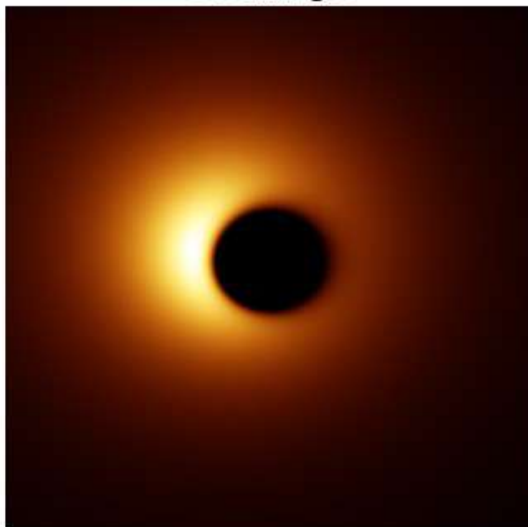


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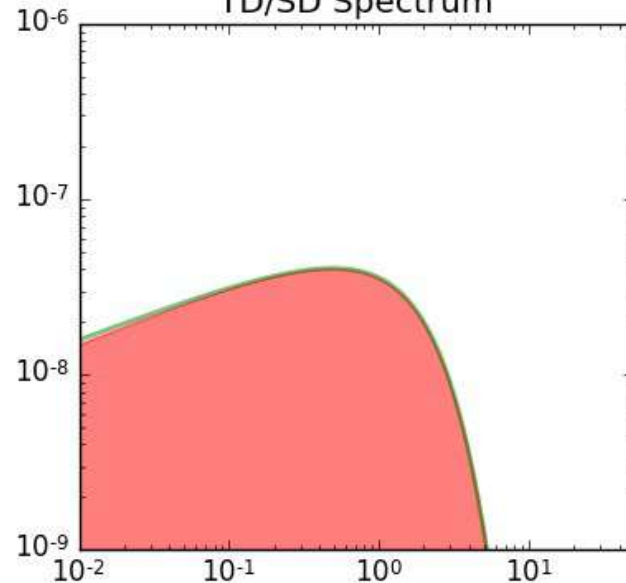
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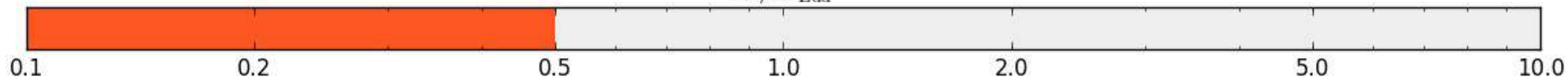
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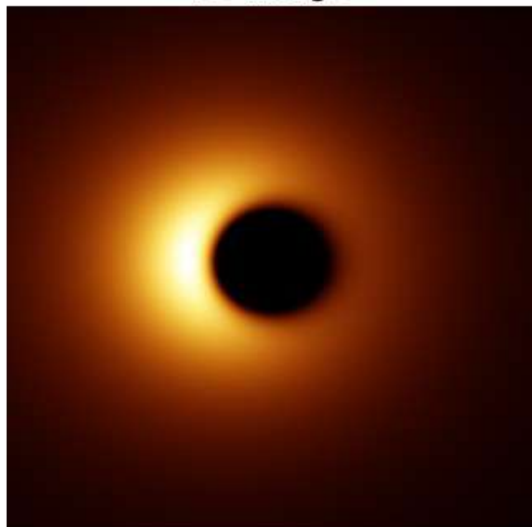


$\dot{M}/\dot{M}_{\text{Edd}}$

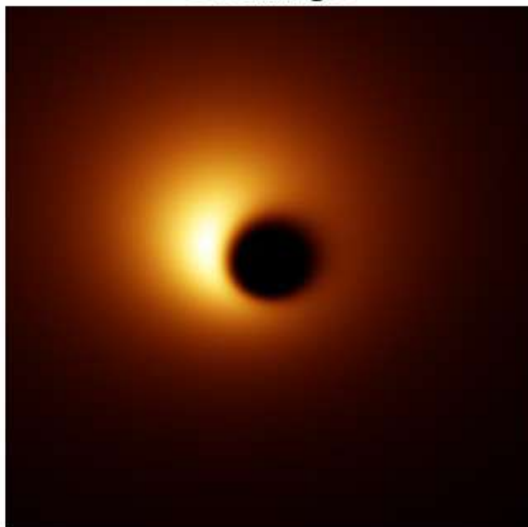


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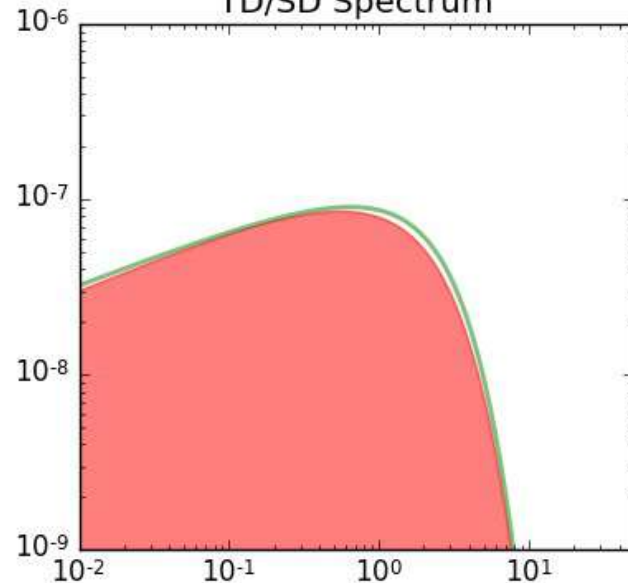
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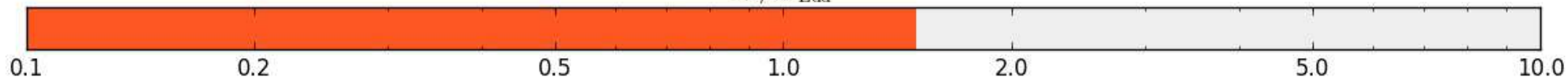
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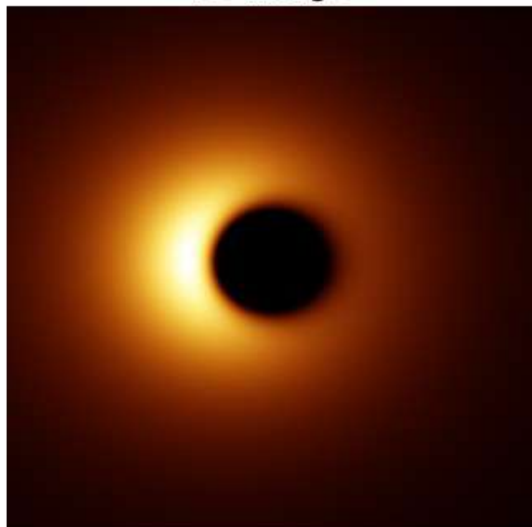


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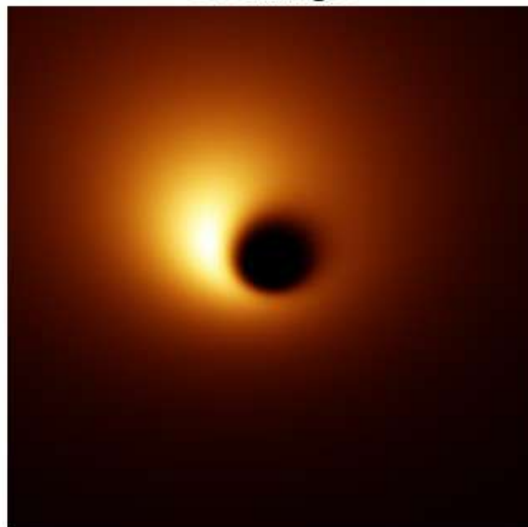


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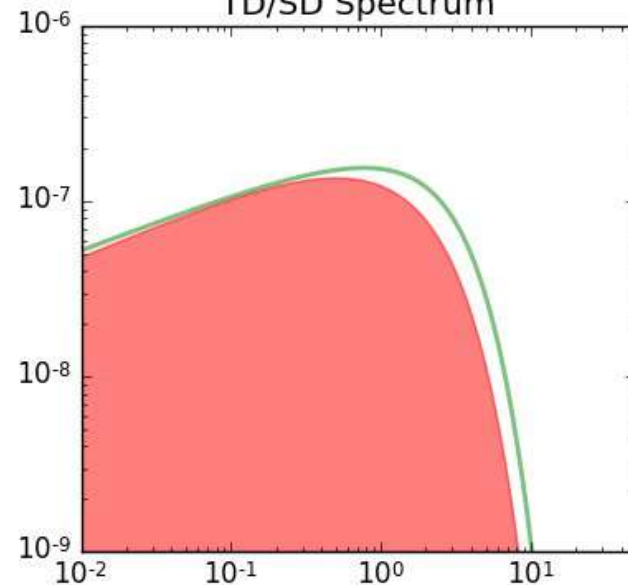
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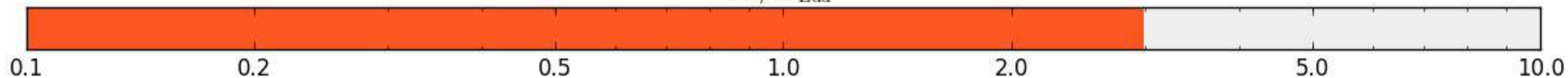
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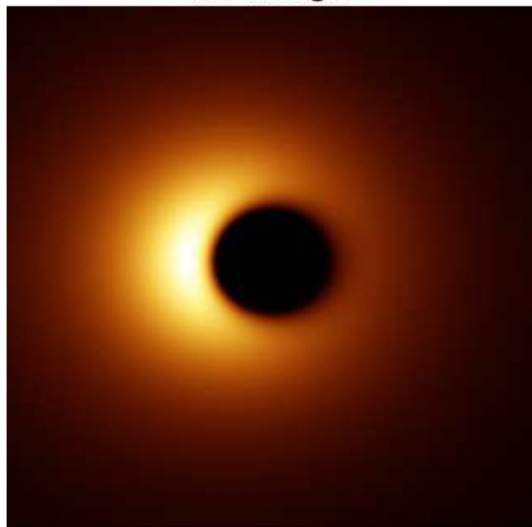


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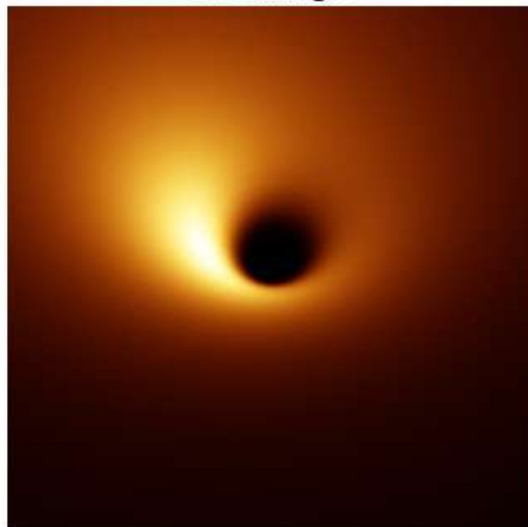


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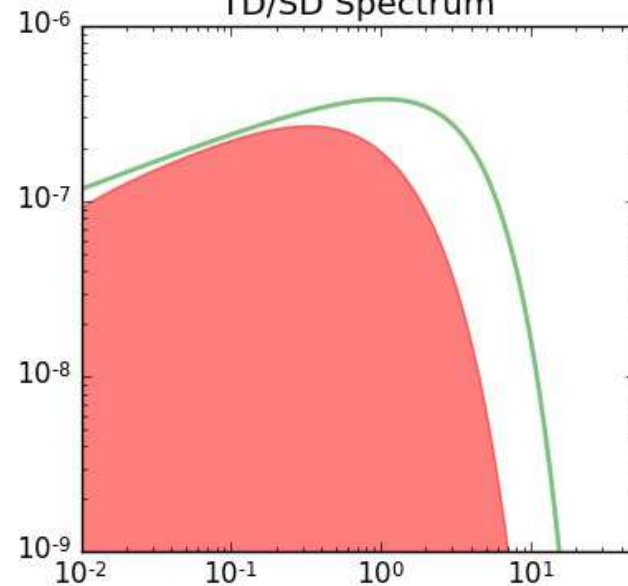
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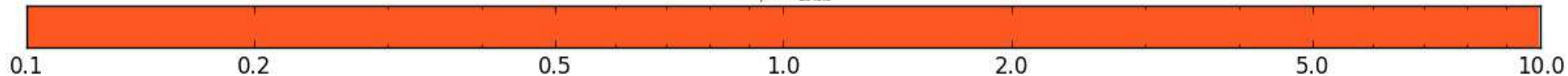
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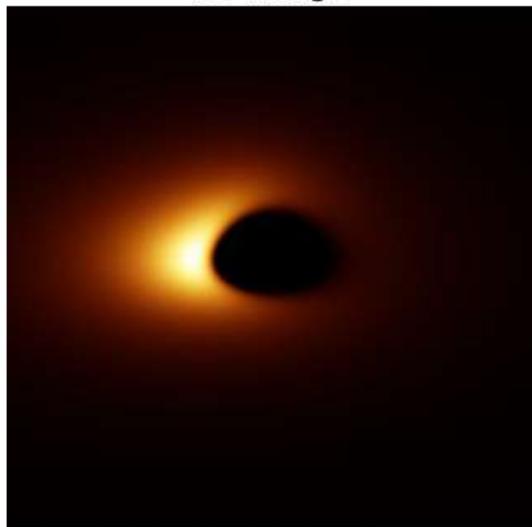


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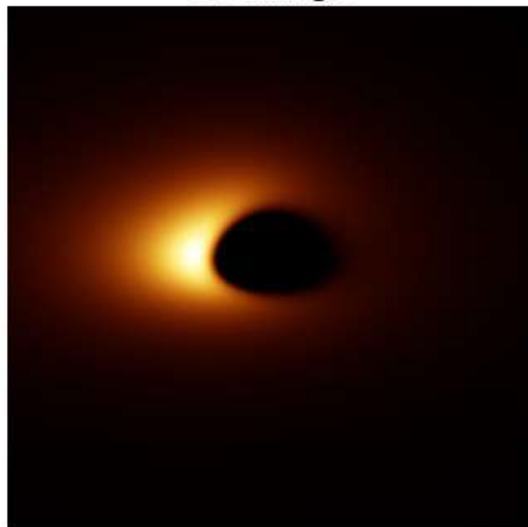


ULX spectra ($a=0.00$, $i=60^\circ$)

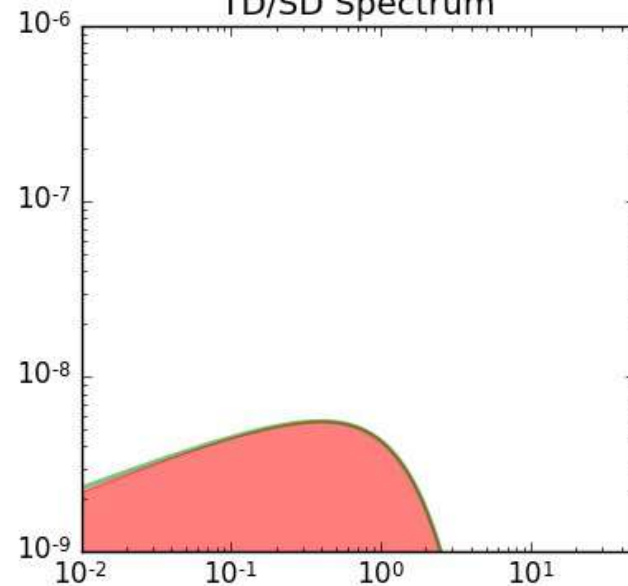
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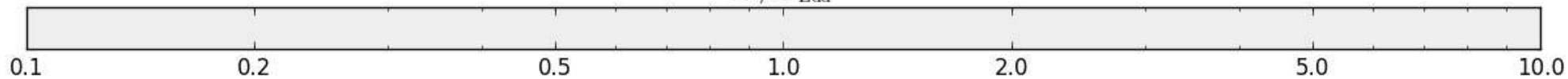
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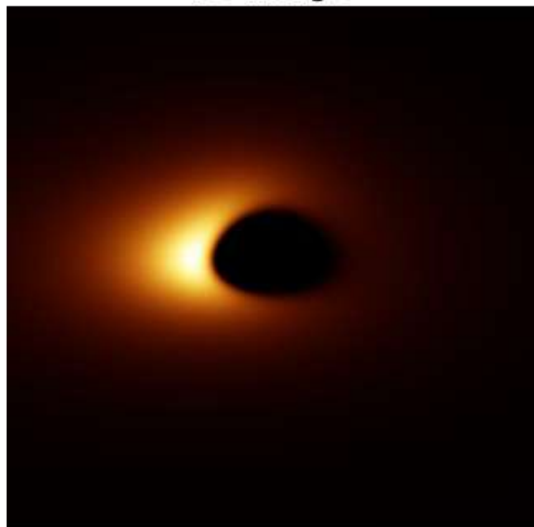


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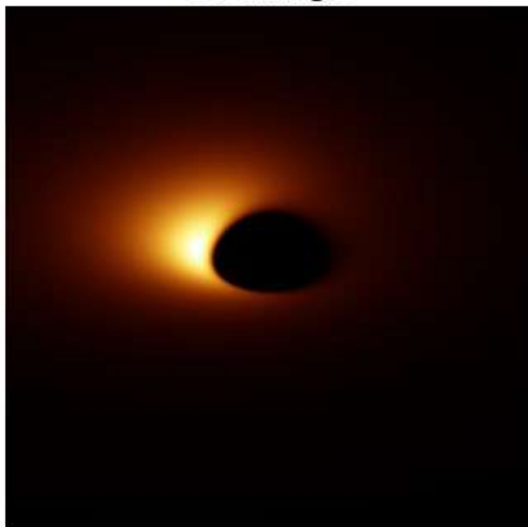


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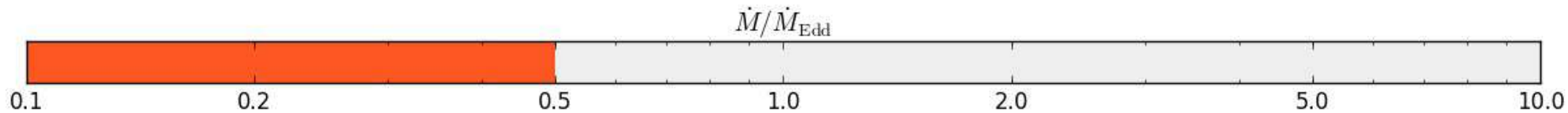
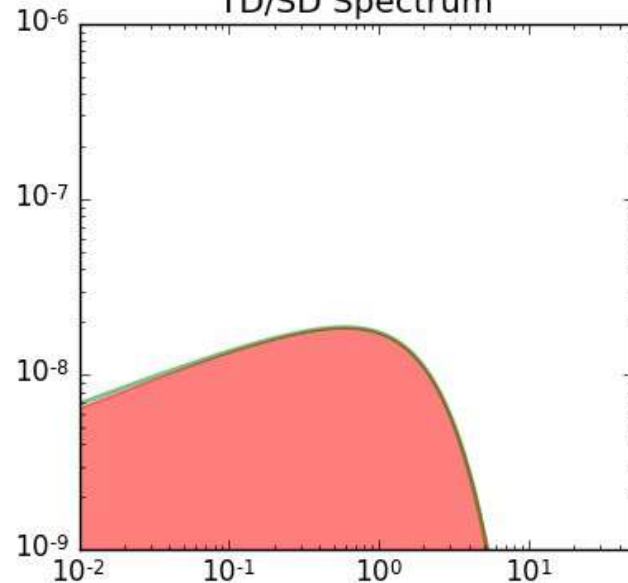
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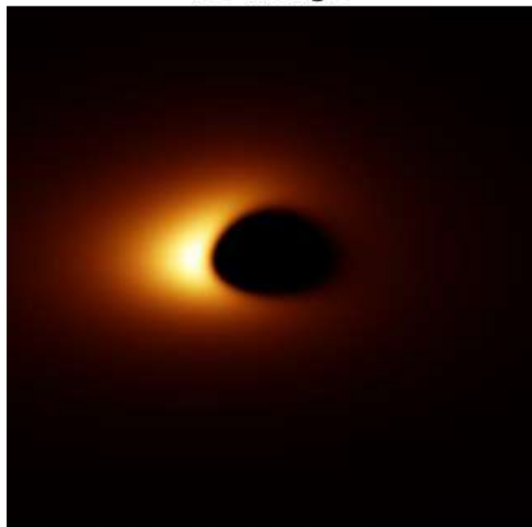


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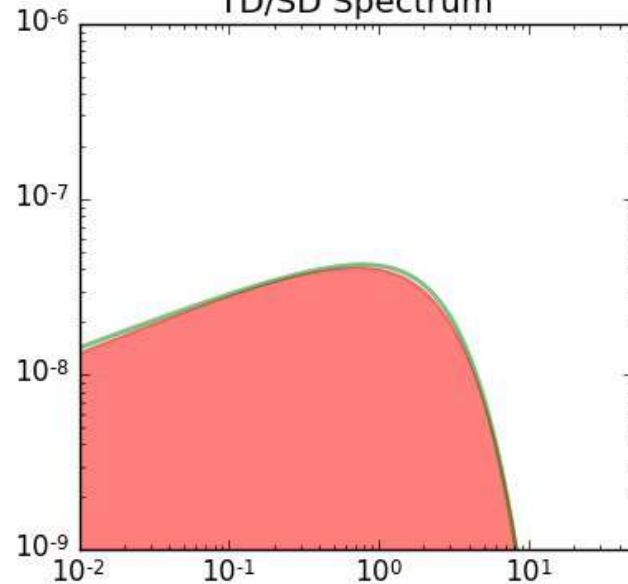
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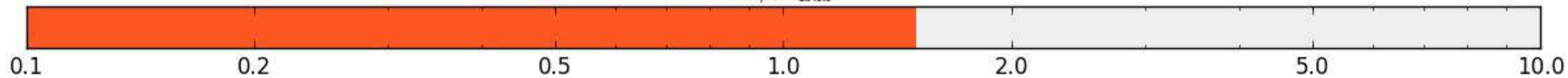
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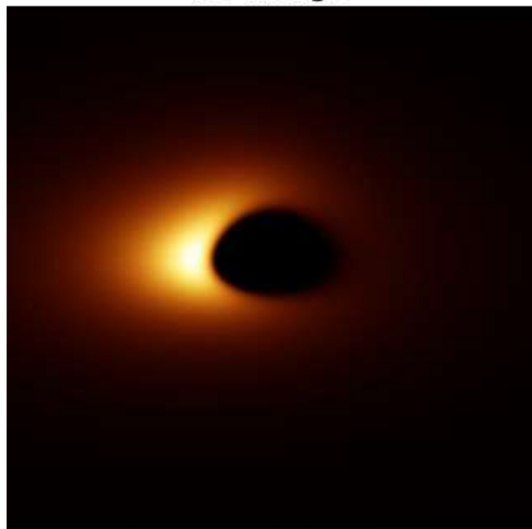


$\dot{M}/\dot{M}_{\text{Edd}}$

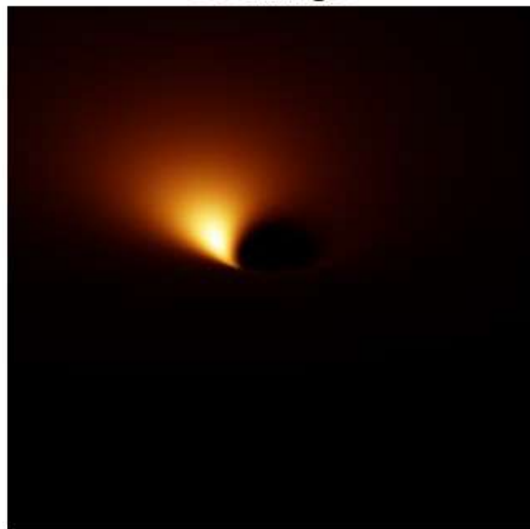


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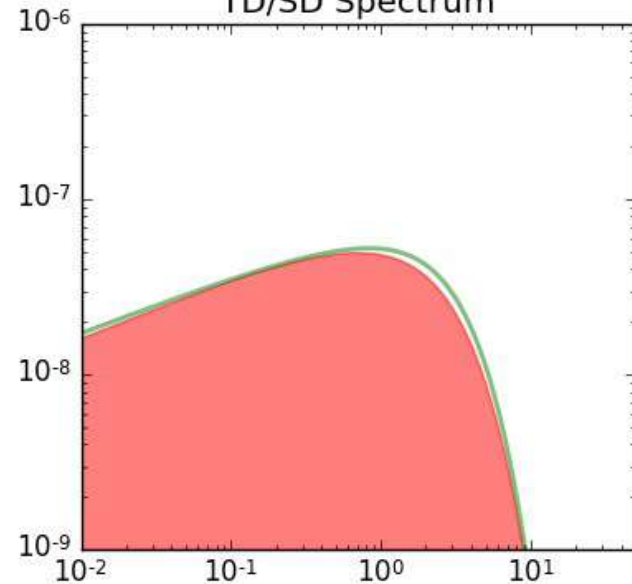
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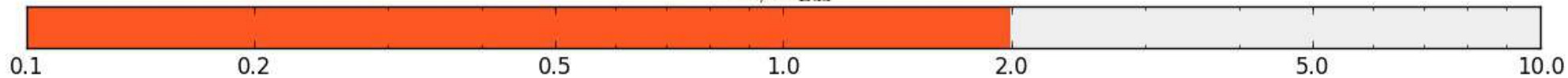
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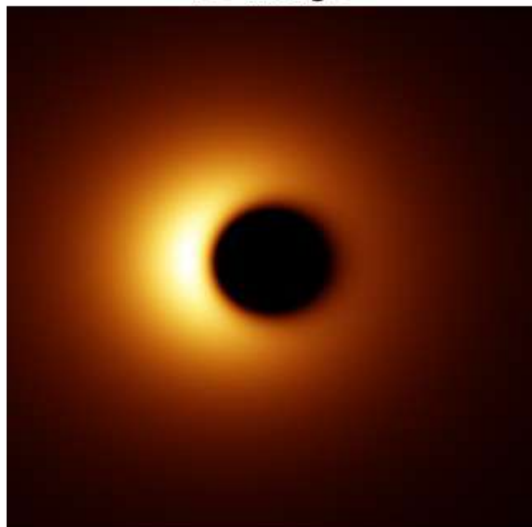


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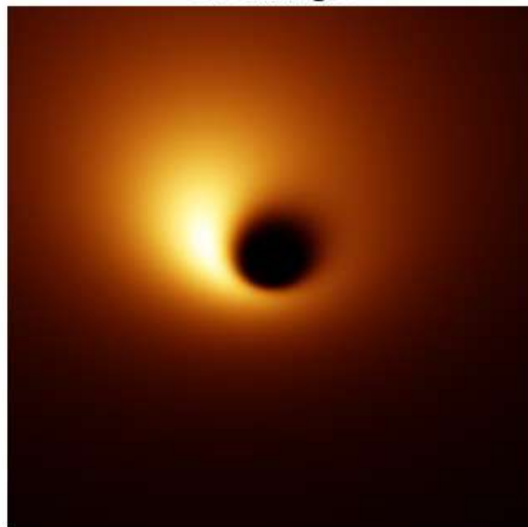


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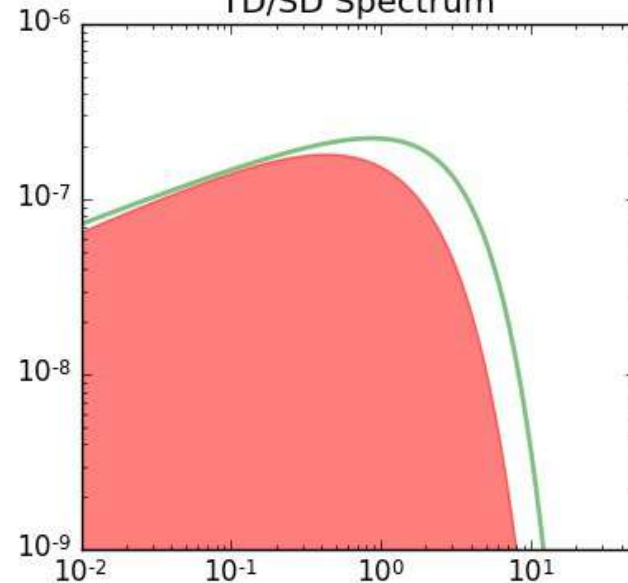
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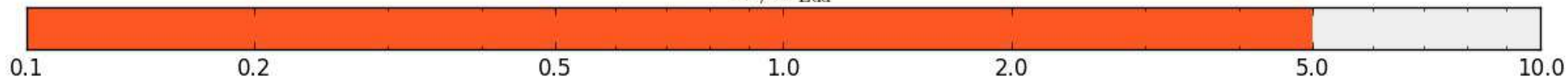
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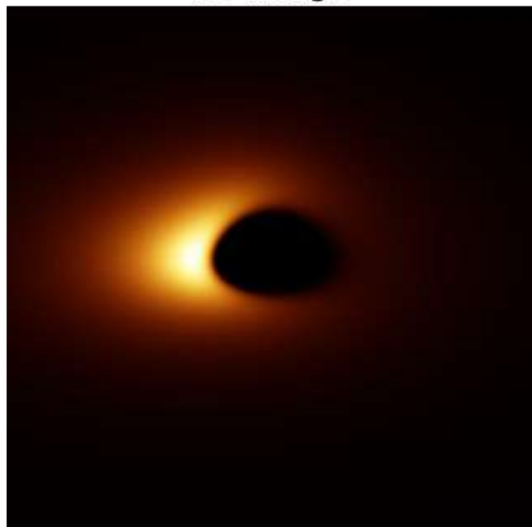


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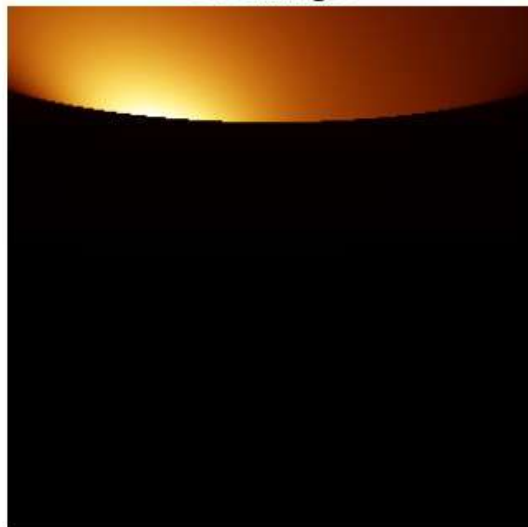


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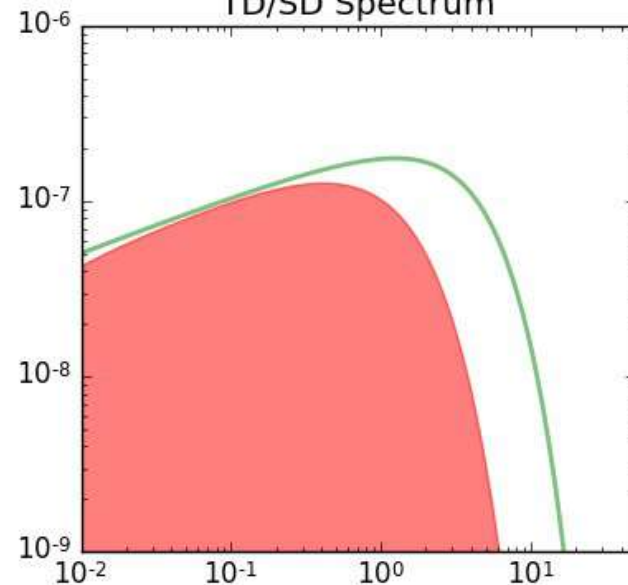
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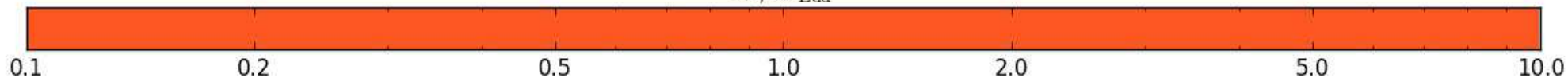
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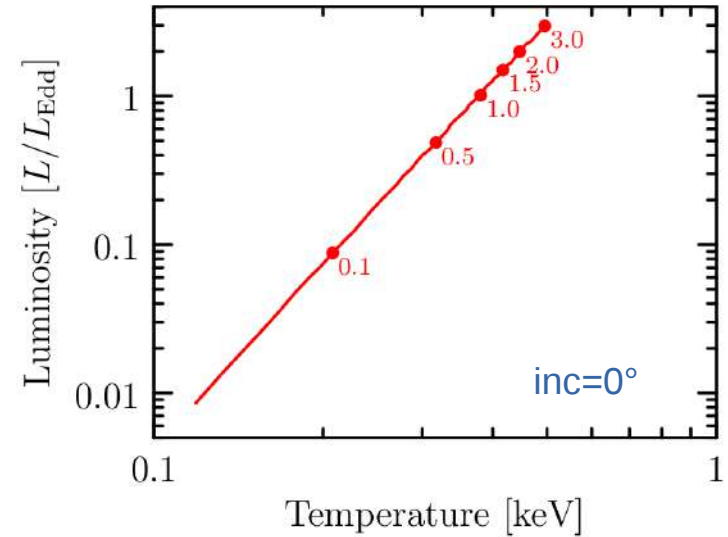
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Luminosity vs. Temperature

L-T plot in super-eddington case:

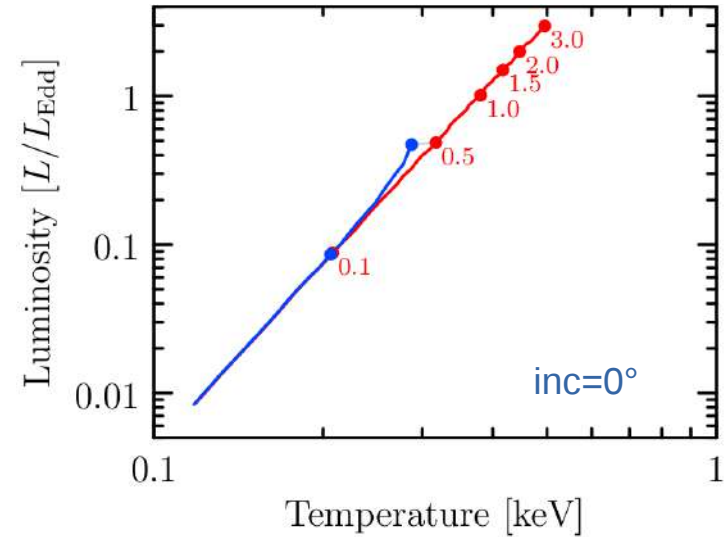
- standard (thin) disks follow $L \sim T^4$ relation
- advection and obscuration effects cause significant deviations from that relation in super-Eddington regime
- the effect is strongly inclination dependent
- observed luminosity can stay around eddington even if mass accretion rate is $\gg 1$
- that has implications for spectral modeling



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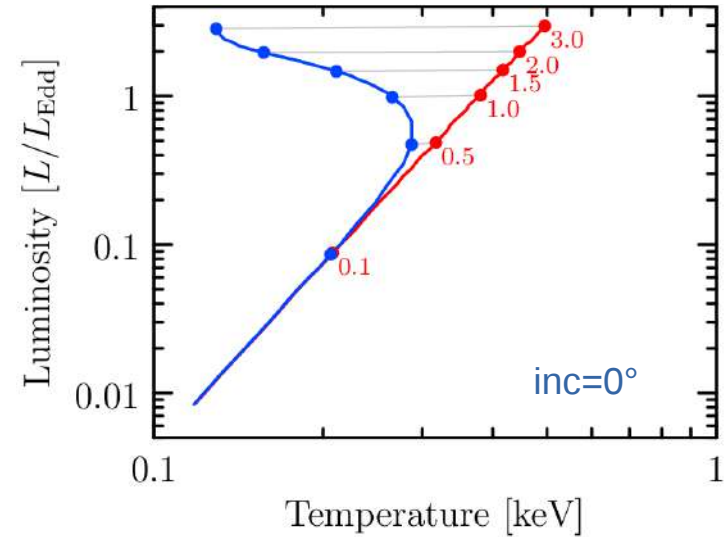
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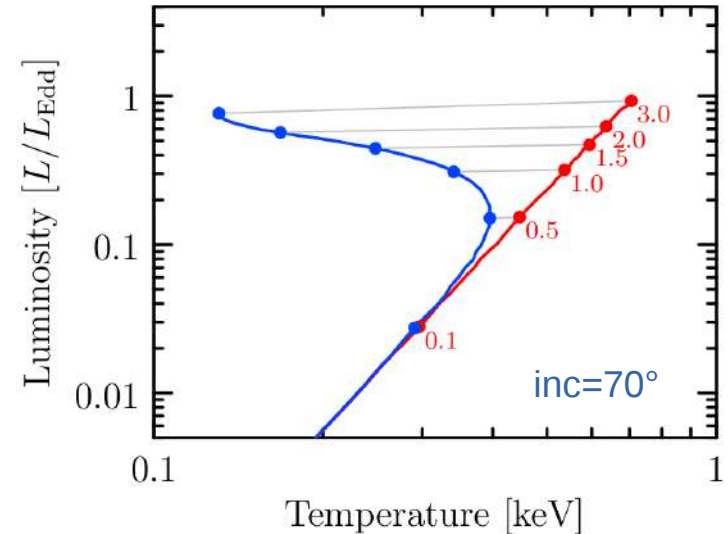
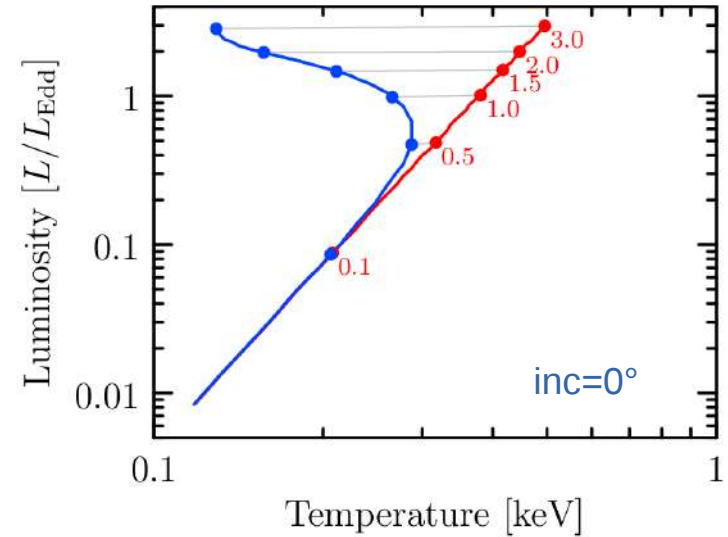
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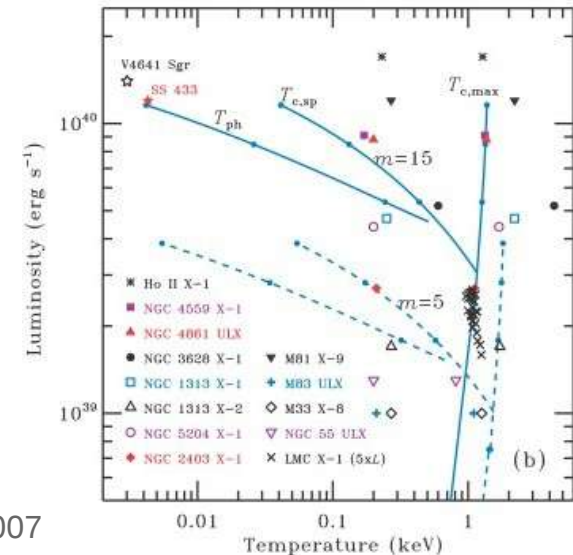
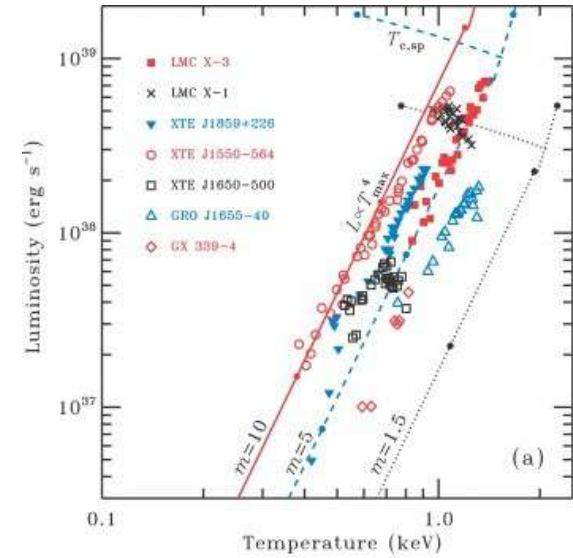
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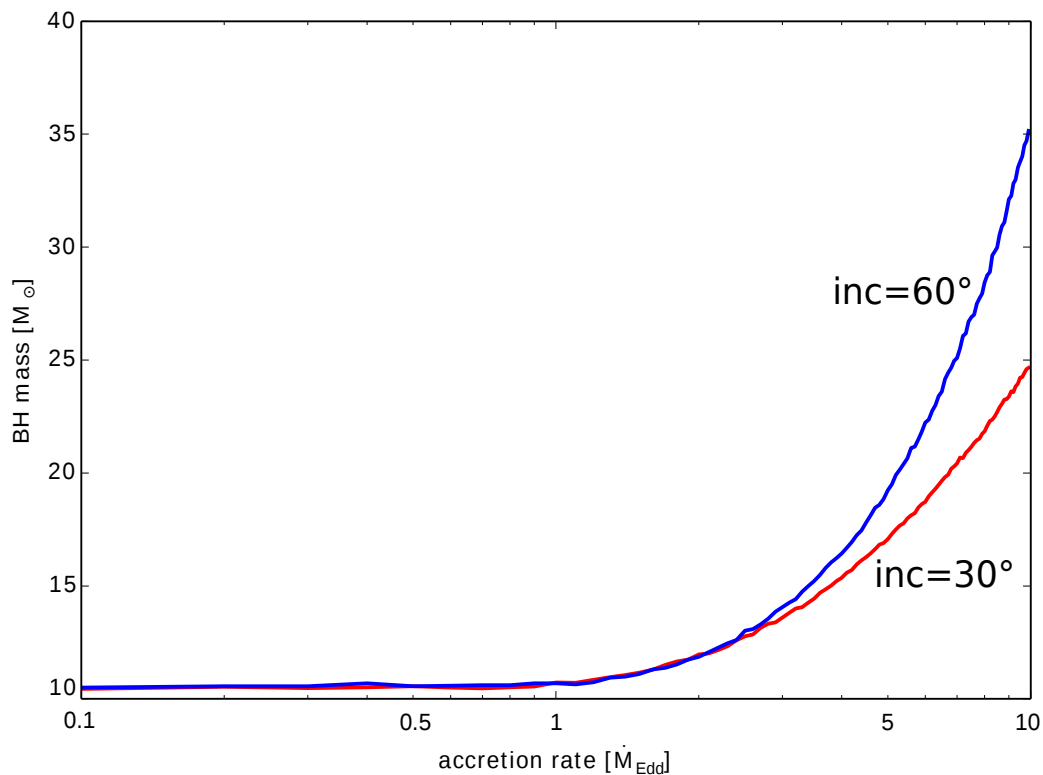
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Mass estimates from thermal spectra

SLIMULX spectra fitted with DISKBB

- simulated SLIMULX spectra are fitted with a thin disk model (DISKBB) and mass is obtained from the fit
- at low \dot{M} , the fit recovers the original mass, but at high \dot{M} , mass is much larger
- it appears to be quite tricky to estimate the ULX source parameters using thin disk models if the disk is strongly radiation pressure dominated
- **masses may be largely overestimated**



Limitations

Model limitations

- vertical equilibrium treatment ($Q \sim R^{-3}$ instead of $Q \sim [R^2 + z^2]^{-3/2}$)
limits H/R to ~ 1
- constant mass accretion rate, the solution misses transfer of gas to outflow
- reflection of radiation in the inner funnel; beaming
- feedback from radiation on the disk structure and shape
- hardening factor treatment

Fixes

- use insight from numerical simulations to apply scaling to the analytic model, possibly with accounting for comptonization in the outflowing wind

Summary

- slimulx model can be used fit BHB UXL spectra
- the model spectra reproduce a turnover in L-T track
- **compared to thin disk models, it gives lower BH masses**