X-ray reflection from slim accretion disks

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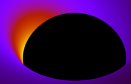


Transient Phenomena and Physical Processes Around Supermassive Black Holes @ TDLI

17 October, 2024

Introduction

- Super-Eddington accretion has been observed in variety of X-ray sources: ULX BHs and pulsars (Kaaret+2017), AGNs (Tsai+2018), TDEs (Gezari2021).
- In super-Eddington accreting system one expects a disk both geometrically and optically thick (Abramowicz+1988).
- X-ray reflection models assume a razor-thin equatorial accretion disk which may provide incorrect results in slim disk regime.

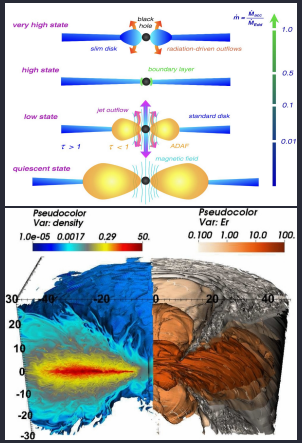
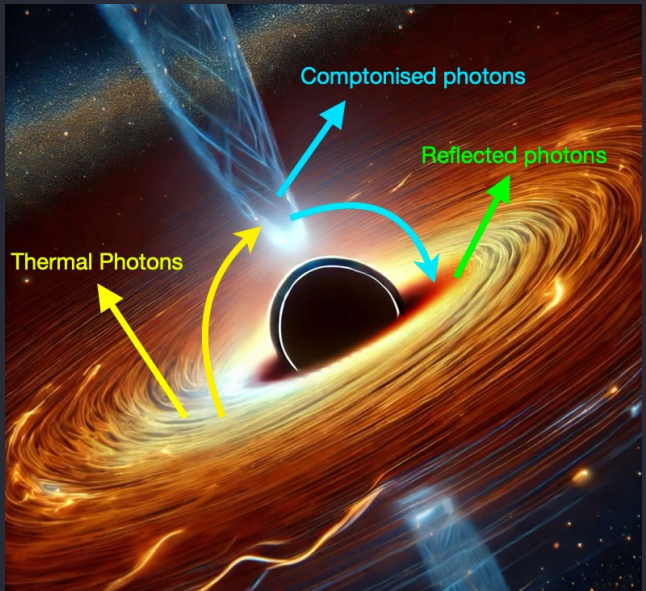
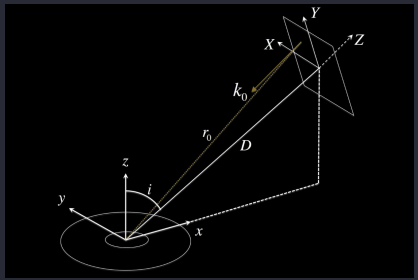


Figure: Müller2004 (top), Jiang+2014 (bottom)

X-ray reflection



X-ray reflection



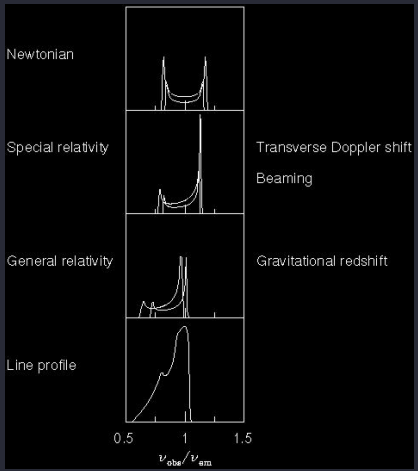
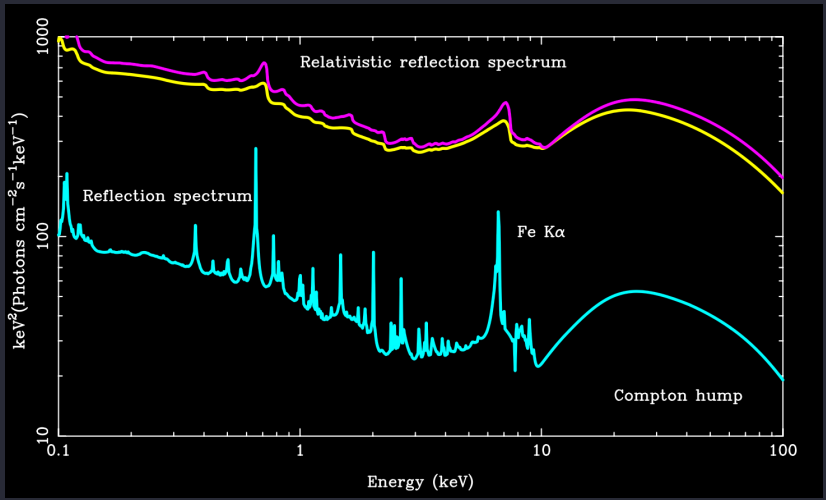


Figure: Bambi2017 (left), Fabian+2000 (right)

X-ray reflection



Evidence of reflection in super-Eddington systems

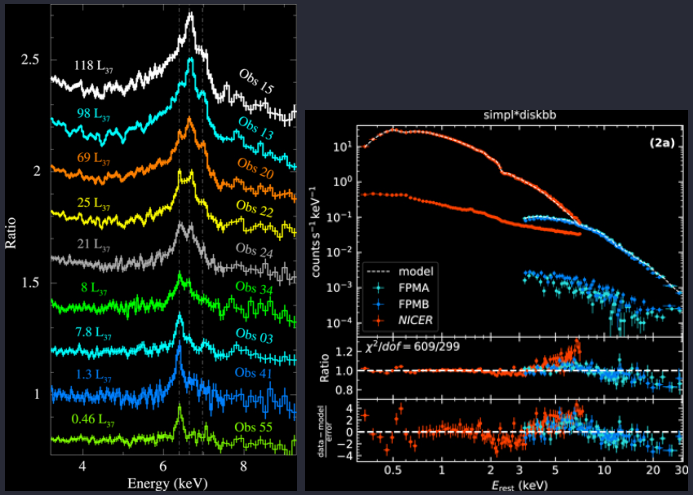


Figure: Left: Galactic pulsar J0243.6+6124 (Jaisawal+2019), Right: TDE AT2021ehb (Yao+2022)

Presenting *REFLUX*

REFLection from Ultraluminous X-ray sources

- First ever reflection model with a slim accretion disk.
- Follows the analytical super-Eddington disk profile (Watarai2006).
- The free parameters of the relativistic in the model are the accretion rate, inner edge and inclination angle.
- The disk thickness is controlled by the accretion rate.
- Made to work with local reflection provided by the family of `xillver` tables similar to the popular `relxill` model.
- Designed to work within XSPEC.

Disk profile

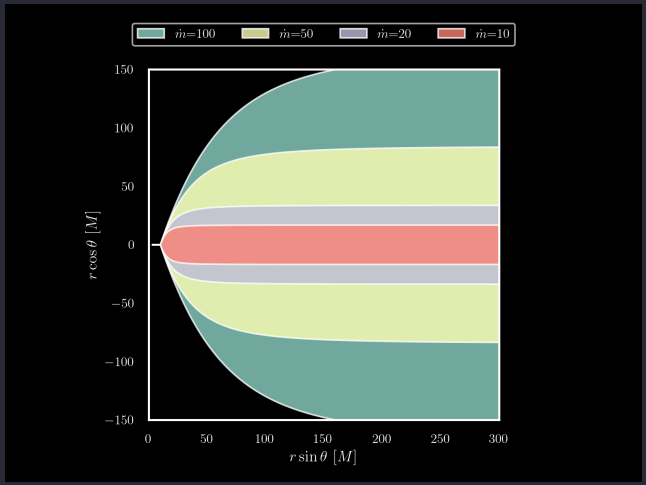


Figure: Shashank+2024

Ironlines

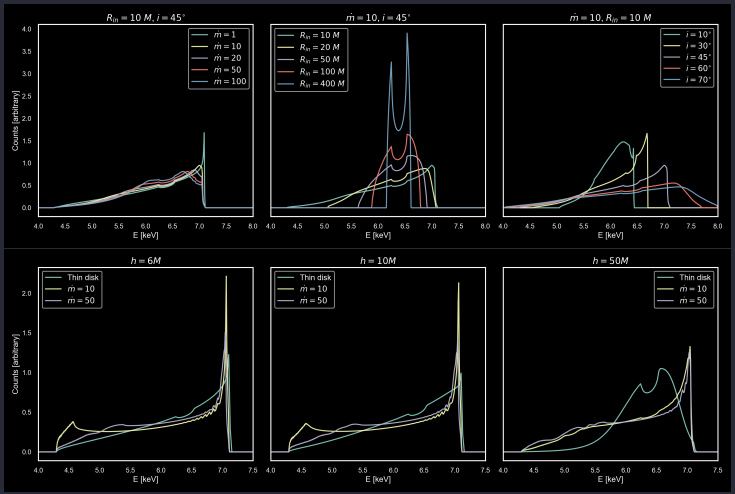


Figure: Shashank+2024

J0243.6+6124 test fit

NICER (ObsID 1050390113, 1 November 2017) and NuSTAR (ObsID 90302319004, 30 October 2017)

Model	Parameter	Unit	Relxill	Reflux
Tbabs	nH	10^{22} cm^{-2}	$0.683^{+0.009}_{-0.011}$	$0.664^{+0.01}_{-0.006}$
Cutoffpl	Γ		$1.423^{+0.009}_{-0.009}$	$1.434^{+0.014}_{-0.009}$
	Ecut	keV	$24.3^{+0.6}_{-0.5}$	$24.8^{+0.3}_{-0.4}$
	norm		$12.4^{+0.5}_{-0.5}$	$12.40^{+0.5}_{-0.29}$
Bbodyrad	kT	keV	$1.213^{+0.019}_{-0.018}$	$1.234^{+0.009}_{-0.013}$
	norm		955^{+21}_{-33}	988^{+25}_{-27}
Reflection	Incl	deg	$15.1^{+4}_{-2.4}$	$25.5^{+3}_{-1.7}$
	$R_{\rm in}$	M	37^{+9}_{-7}	34^{+8}_{-7}
	log(ξ)	erg cm s^{-1}	$3.54^{+0.05}_{-0.07}$	$3.29^{+0.03}_{-0.12}$
	$A_{\rm Fe}$	solar	$4.2^{+1.4}_{-1.2}$	$2.39^{+0.5}_{-0.27}$
	norm		$0.050^{+0.007}_{-0.005}$	$0.0255^{+0.001}_{-0.0017}$
χ^2/ν			2855.14/2624	2857.12/2624

Summary and future directions

- We present the first data analysis model which can be used for spectral fitting of X-ray reflection in super-Eddington regime.
- With initial fitting we see substantial difference in inclination angles and iron abundance compared to thin disk model. More analysis to come.
- The model will updated to have an option to fit data for reflection from optically thick outflow.
- I am working towards a self-consistent thermal+reflection model which could open the possibility to measure the spin of the BH in a TDE event.
- To use the model please contact me: *swarnim@fudan.edu.cn*

Interest in super-Eddington rising

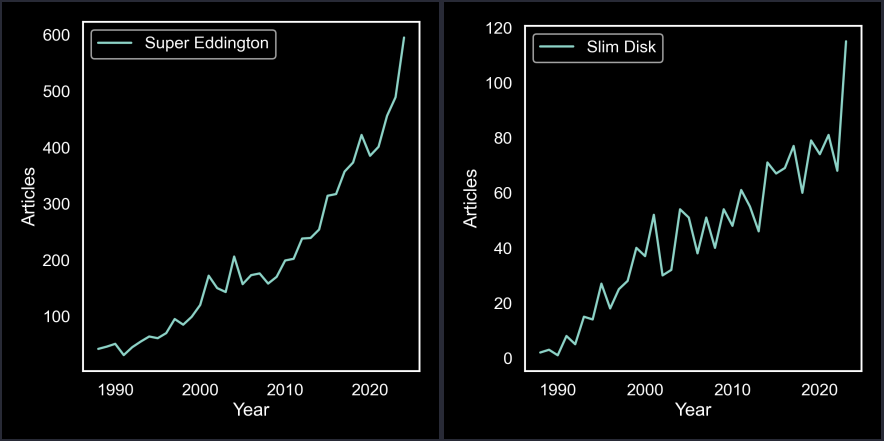


Figure: ADS data

谢谢
Thank You

"It is an astonishing feat of deciphering that we should have been able to infer an orderly scheme of natural knowledge from such indirect communication."

- Arthur Stanley Eddington, Science and the Unseen World