BLACK HOLES AT DIFFERENT FLAVOURS

HERA 2026
WE-HERAEUS-EAS WORKSHOP FOR EARLY CAREER RESEARCHERS IN ASTRONOMY

WILHELM UND ELSE HERAEUS-STIFTUNG

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TALES
Time-domain Analysis to study the Life-cycle & Evolution of Supermassive black holes

A magnetically supported disk-corona model for changing-look active galactic nuclei transitions

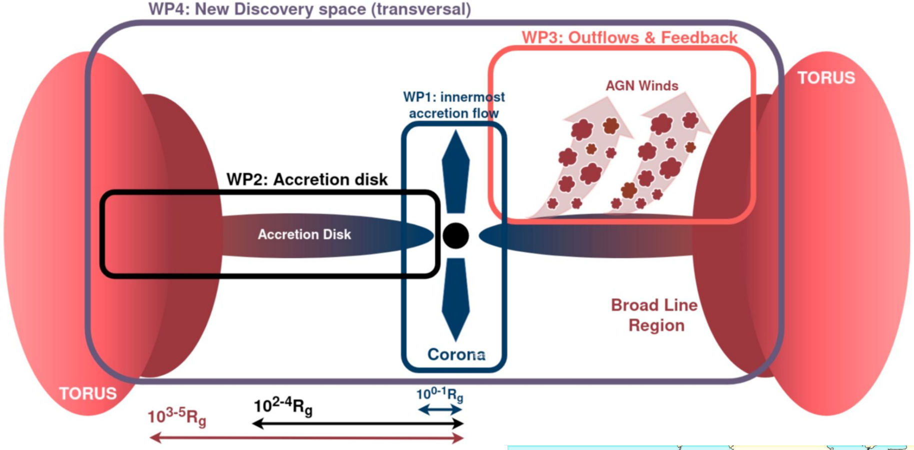
Marios Kouzis

PhD student, CAMK

Supervisor: **Agata Różańska**

Collaborators: **Debora Lančová, Bożena Czerny, Dominik Gronkiewicz**

TALES: **T**ime-domain **A**nalysis to study the **L**ife-cycle and **E**volution of **S**upermassive black holes

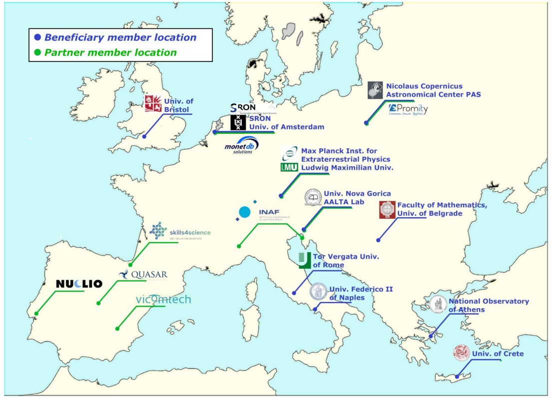





WP2: Accretion disk


Team:

10 astrophysics research groups
11 partners (industrial and academic)



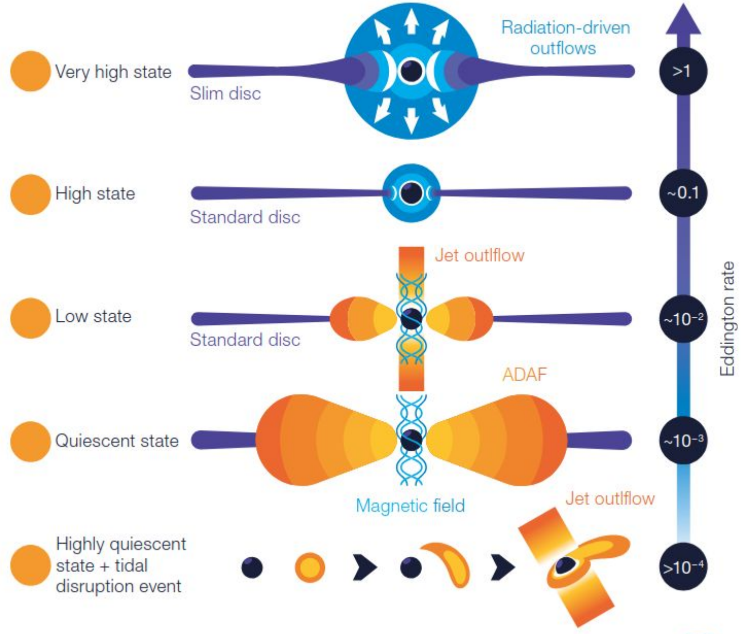
Key Questions

- ❑ Accretion disk structure
- ❑ Black hole properties
- ❑ Testing unified models

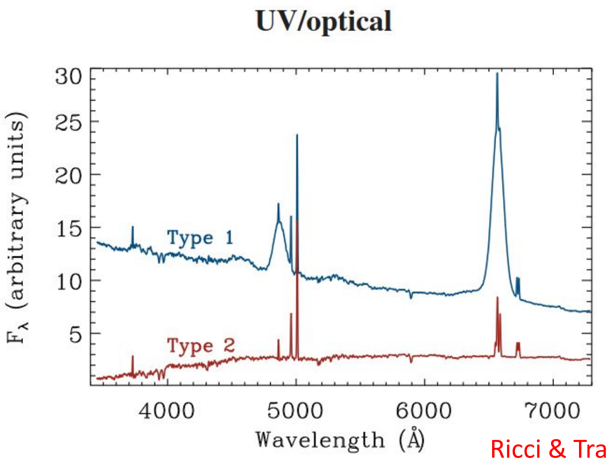
Sleep, wake up, repeat

- **AGN are highly dynamic engines**

→ changing states

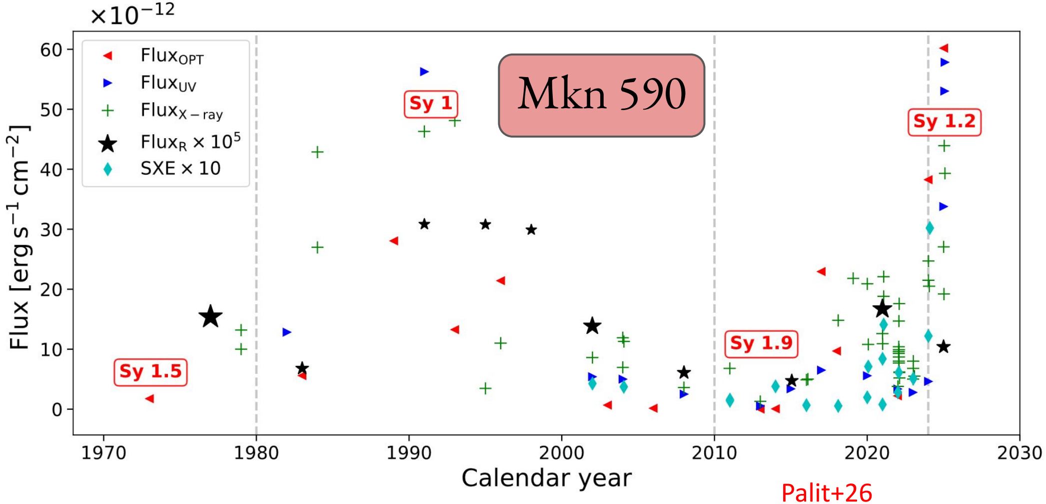


Credits: J. Utreras/F. Bauer (CATA)



Ricci & Trakhtenbrot 22

physical driving mechanism?

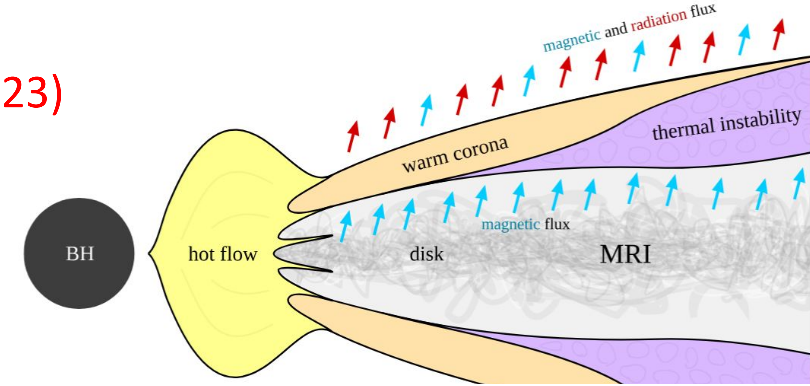


Palit+26

diskvert to the rescue (Gronkiewicz+20,+23)

Code to compute 1D vertical structure of magnetic accretion disks around black holes

input parameters: M_{BH} R λ_{Edd} α_B



Credits: D. Gronkiewicz

hydrostatic equilibrium

+

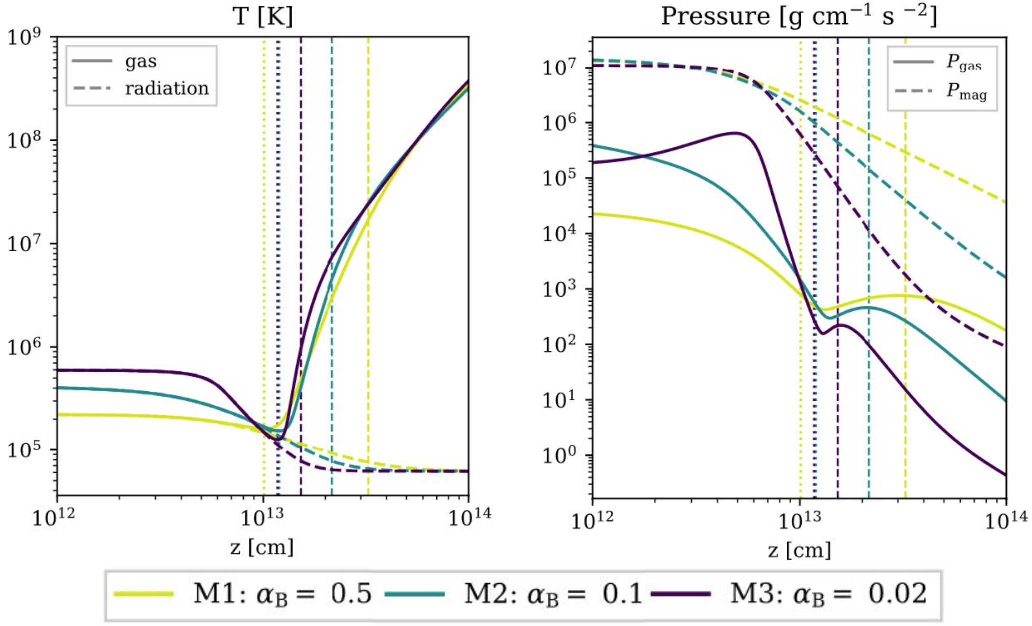
magnetic heating = radiative cooling

workflow

SS73 guess

structure relaxation

corona relaxation



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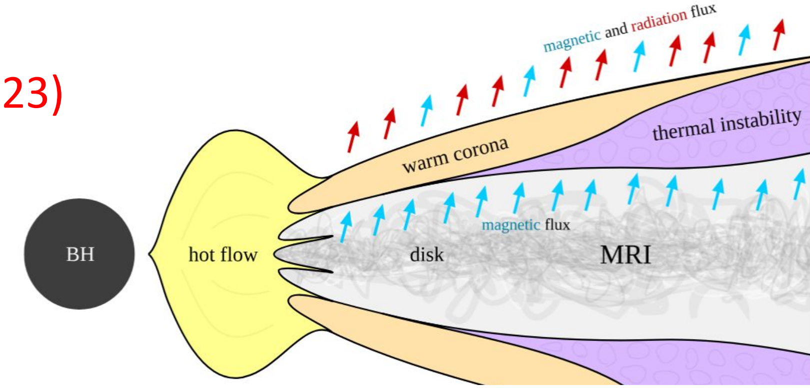
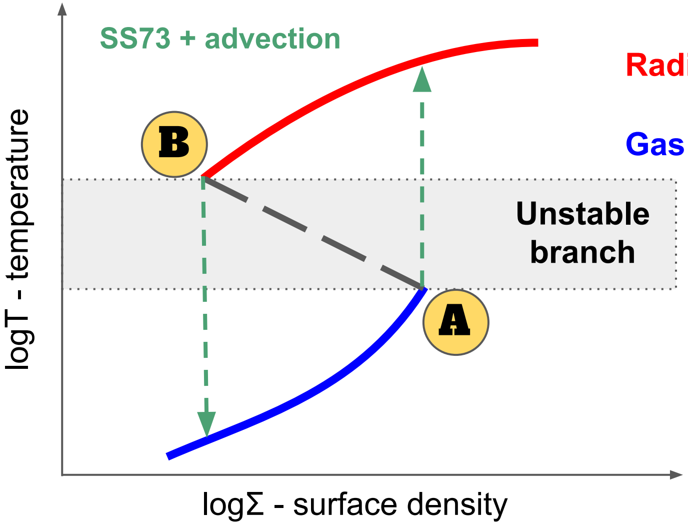


Credits: D. Gronkiewicz

Two diagnostics:

S-curve diagram



Radiation pressure dominated

Gas pressure dominated

Relevant timescales

$$t_{\rm th} = \frac{\text{energy content}}{\text{heating/cooling rate}}$$

$$t_{\rm visc} = \frac{R}{v_r} = \frac{2\pi R^2 \Sigma}{\dot{m}}$$

$$t_{\rm front} = t_{\rm th} \times \frac{R}{H}$$

Magnetic S-curves

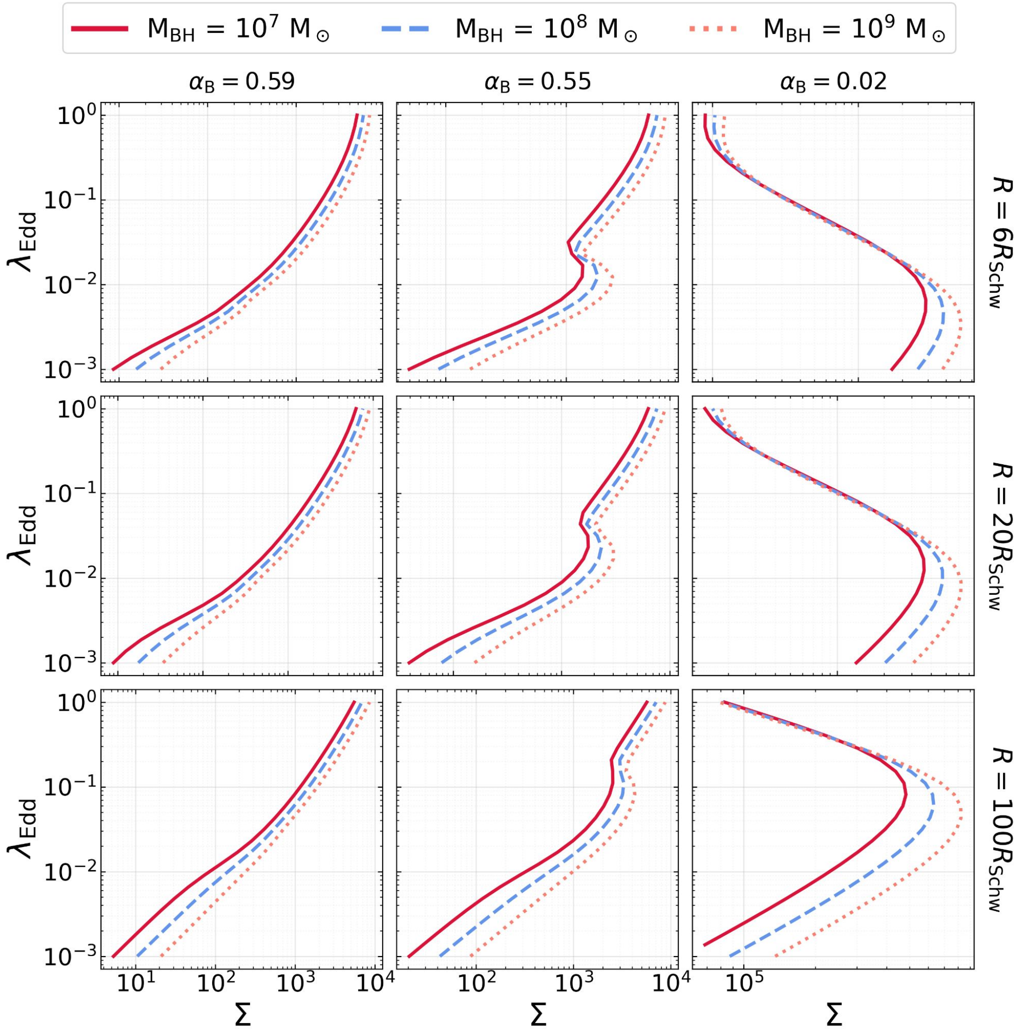
MAGNETIC STABILIZATION

RADIAL DEPENDENCE

MASS INDEPENDENCE

New stable upper branch:

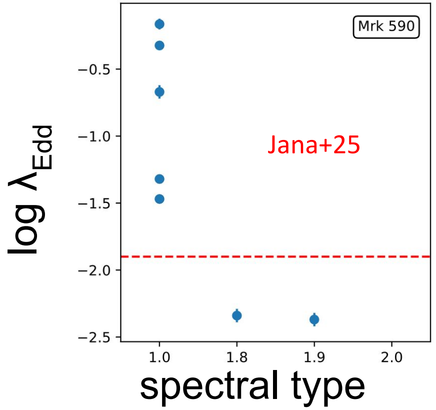
1. *radiatively efficient*
2. *radiation-pressure supported*
3. *magnetic-pressure stabilized*

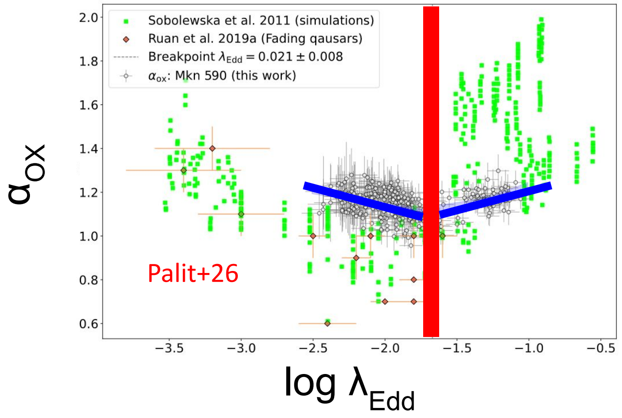


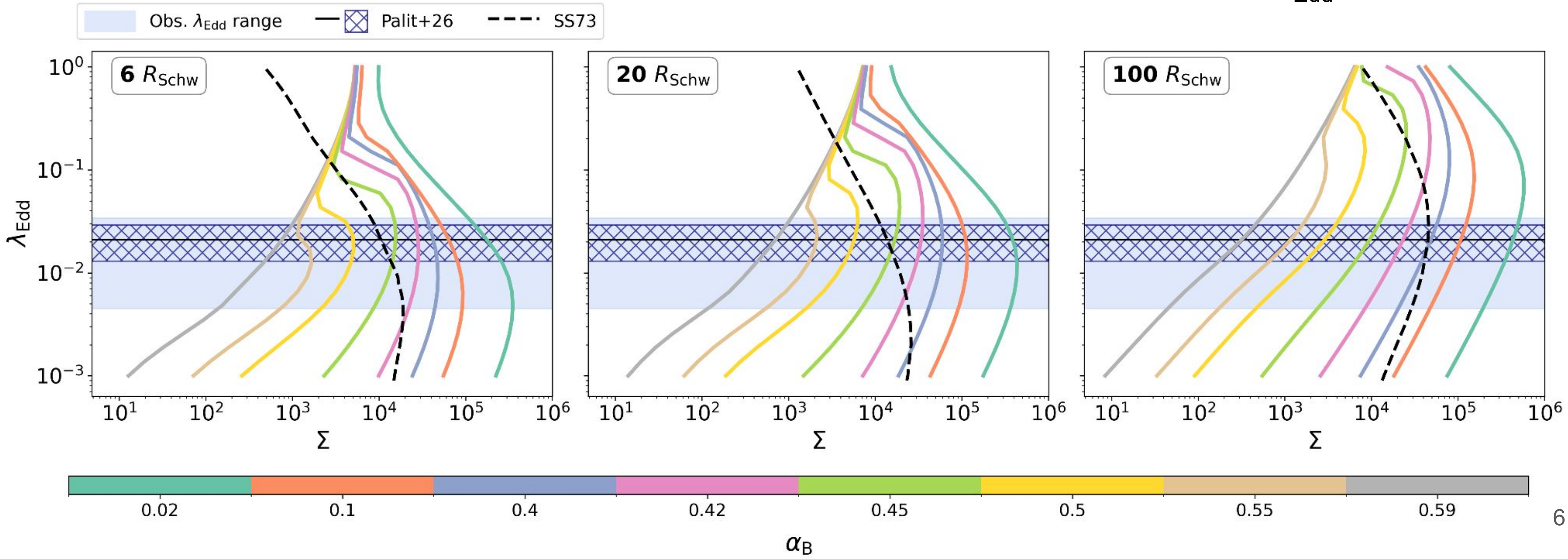
The case of Mkn 590

One of the best-studied nearby CLAGN

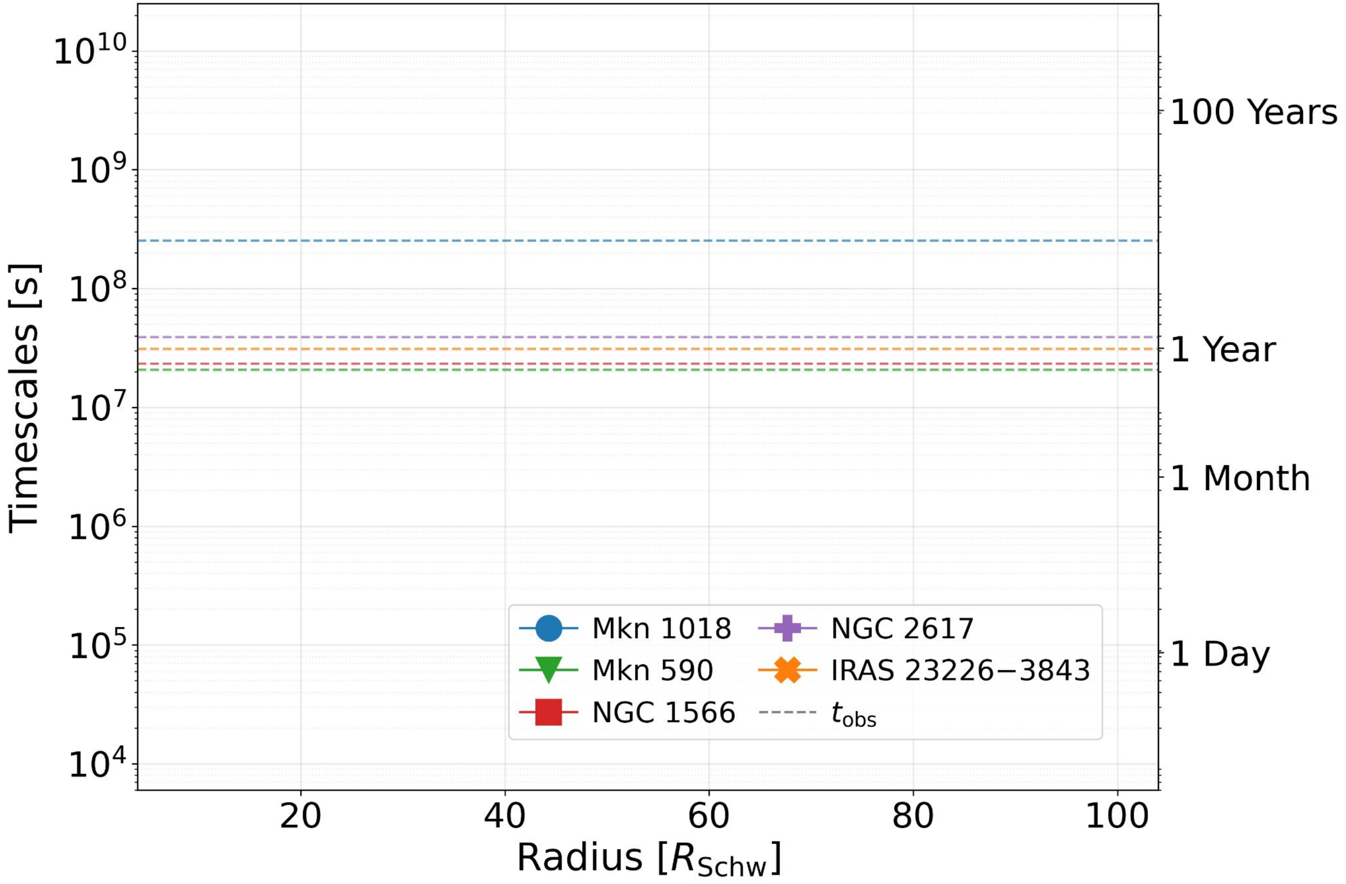
break at λ_{Edd} = 0.021 ± 0.008







It’s about time



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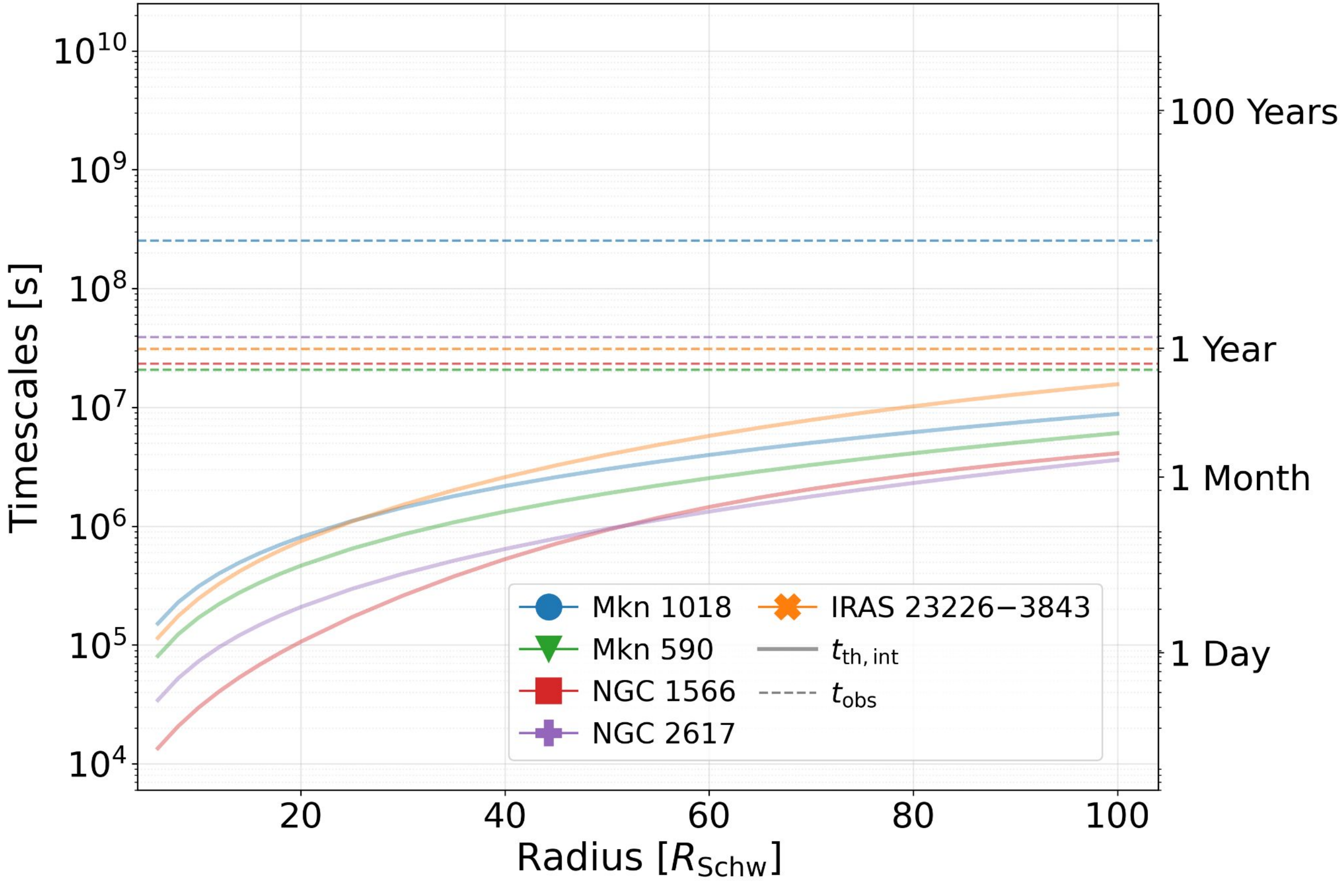

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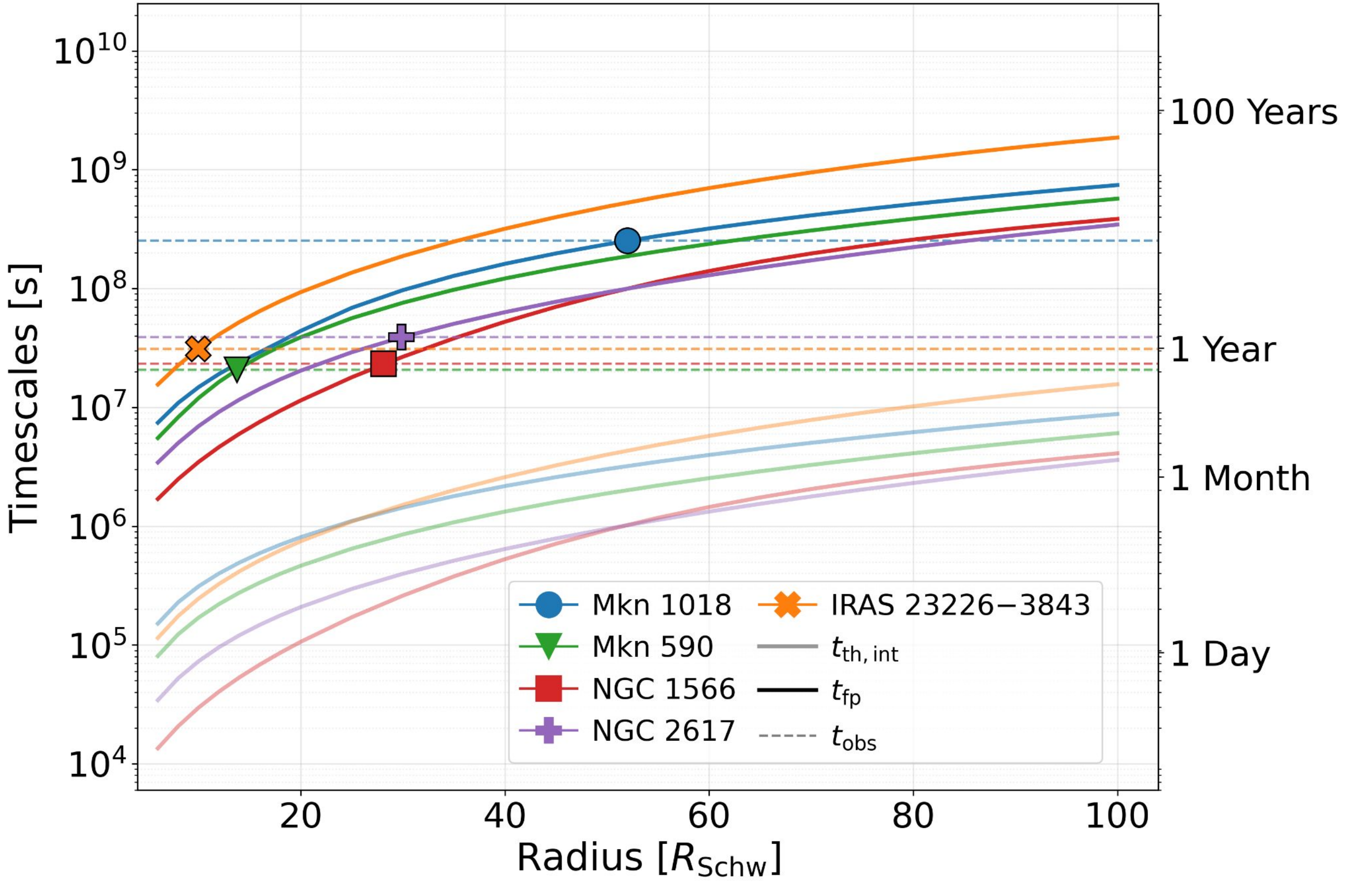

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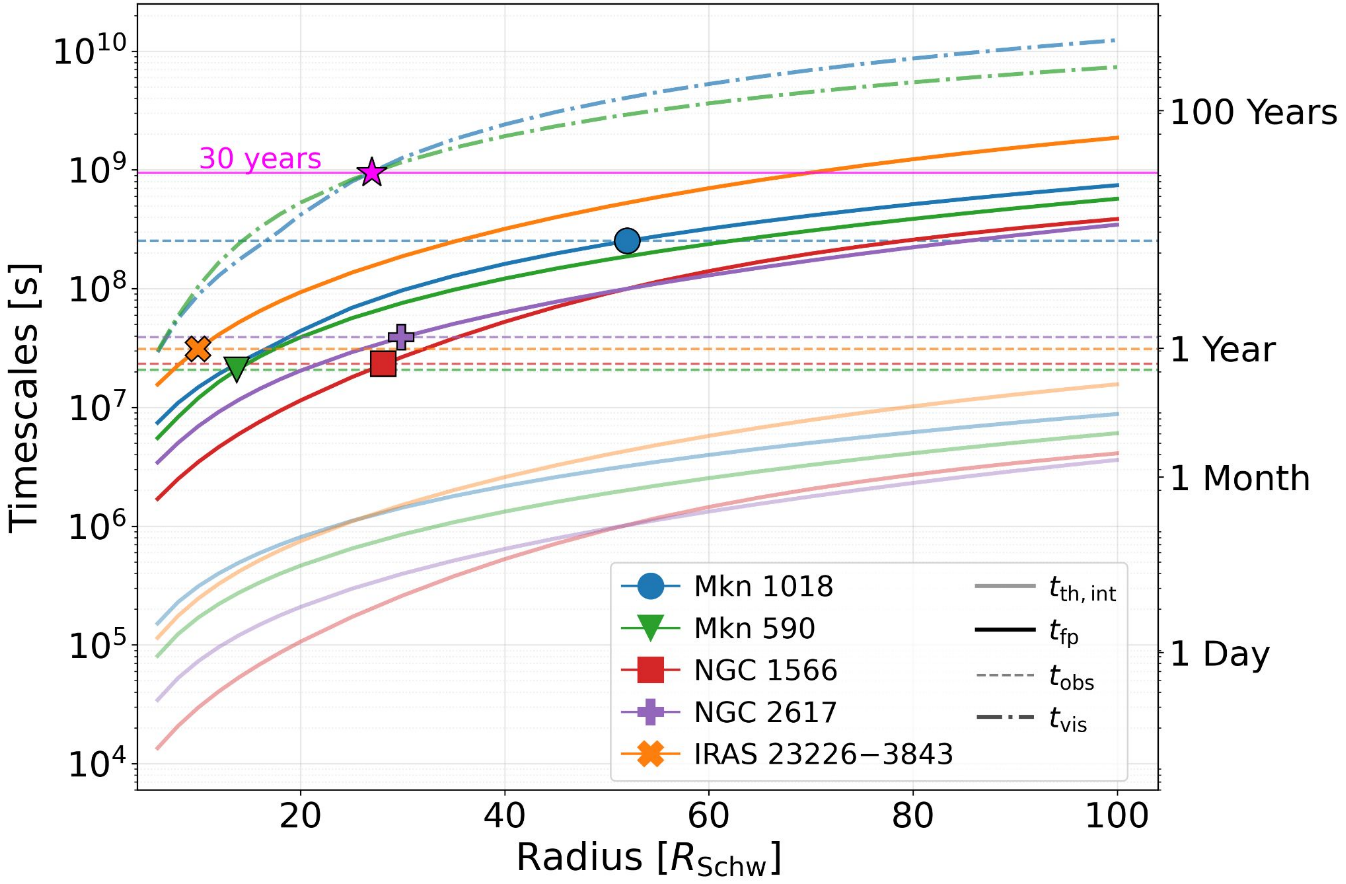
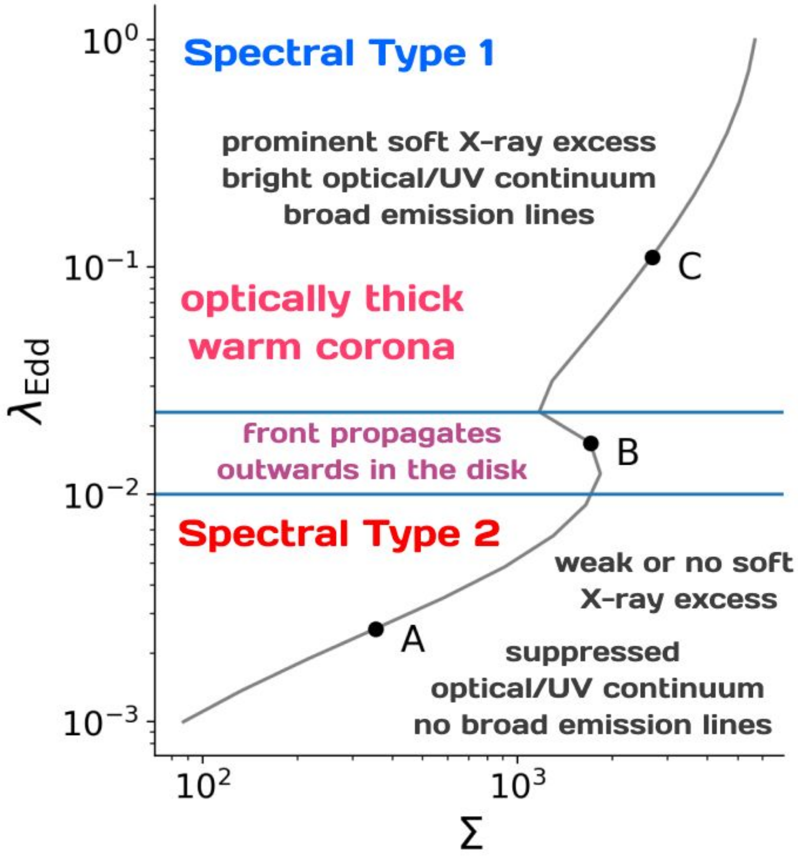
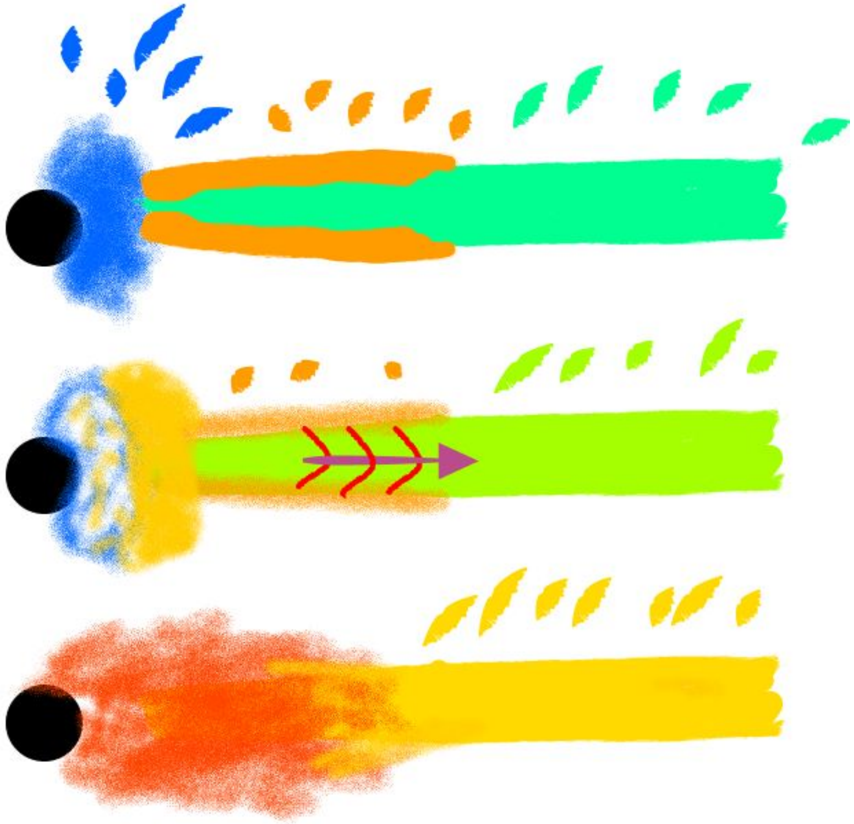


A new magnetic limit cycle



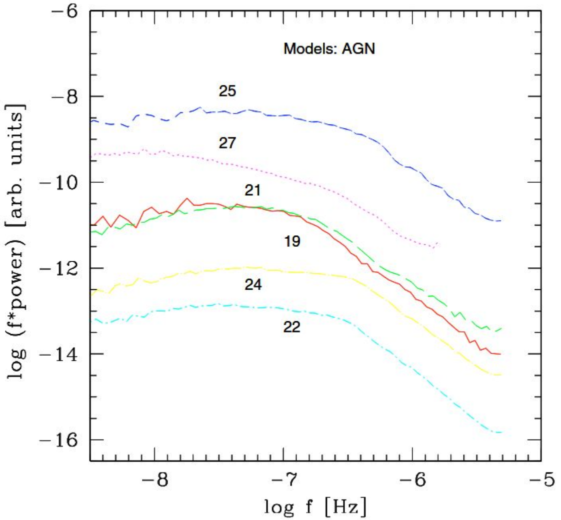


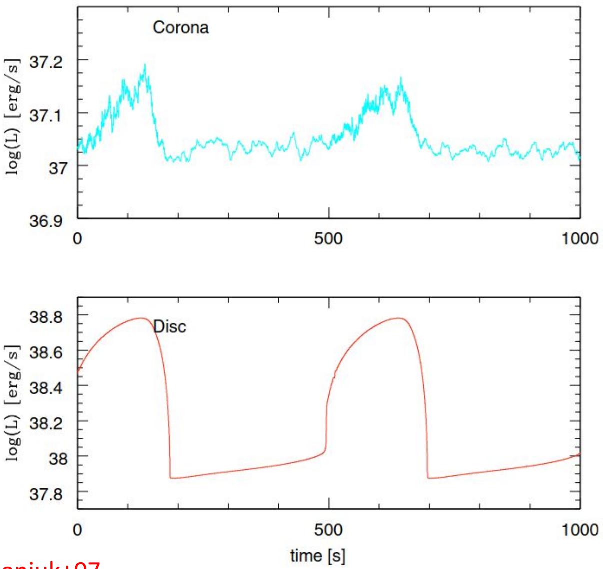
Moving forward

~~static solution~~

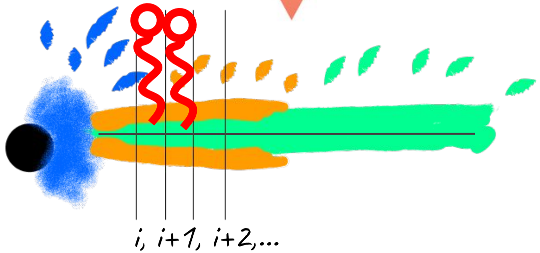
$$\left[\frac{\partial}{\partial t} + \text{mass exchange}\right] :$$ new equations

predictions on multiwavelength variability





Janiuk+07



Per timestep, at every annulus R_i

state update by coupling a radial finite-volume step with an implicit vertical solve

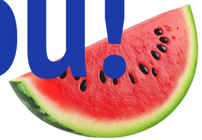
Conclusions

- ❑ Strongly magnetized configurations necessary to match CL transition λ_{Edd}
- ❑ Both diagnostics localize the instability inside ~10-30 R_{Schw}
- ❑ Magnetic S-curve introduces **new stable upper branch**. Indication for a new limit cycle!
- ❑ CL events are predicted to occur at a universal λ_{Edd}
- ❑ Mkn 590 provides the best test yet. α_B = 0.55 and R ~ 6-20 R_{Schw}
- ❑ t_{fp} explains singular CL events, t_{vis} explains repetitive ones - both at few tens of R_{Schw}

Want to learn more?
Read the full article!

Kouzis *et al* 2026 *ApJL* **1007** L6

Thank you!



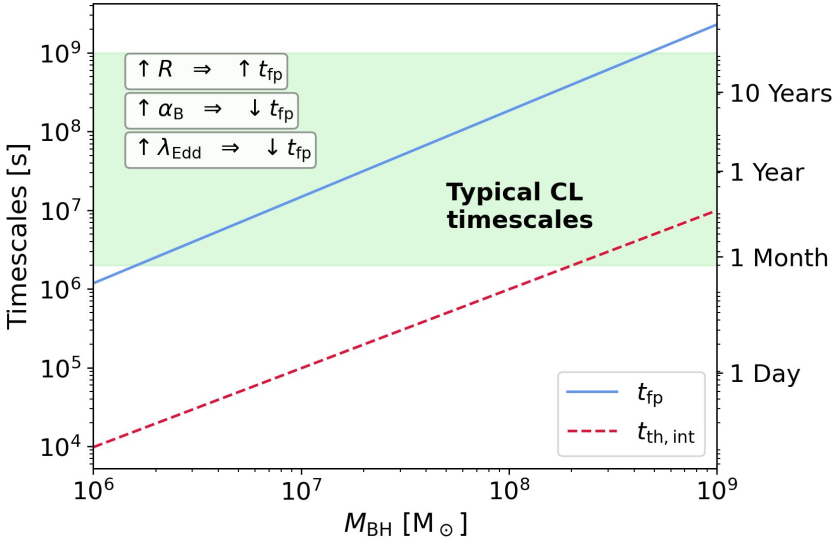
Backup slides

t_{fp} vs M_{BH}

$$t_{\rm th}(z) = \frac{E_t(z)}{\mathcal{H}(z)}, \qquad \text{for}$$

$$E_t(z) = \frac{5}{2}\,P_{\rm gas}(z) + 4\,P_{\rm rad}(z) + 2\,P_{\rm mag}(z)$$

$$t_{\rm th,int} = \frac{\int_{-H}^{H} E_t(z)\,dz}{\int_{-H}^{H} \mathcal{H}(z)\,dz}$$



Full sample: