Modified models of radiation pressure instability as a potential cause of Changing-Look AGN phenomenon

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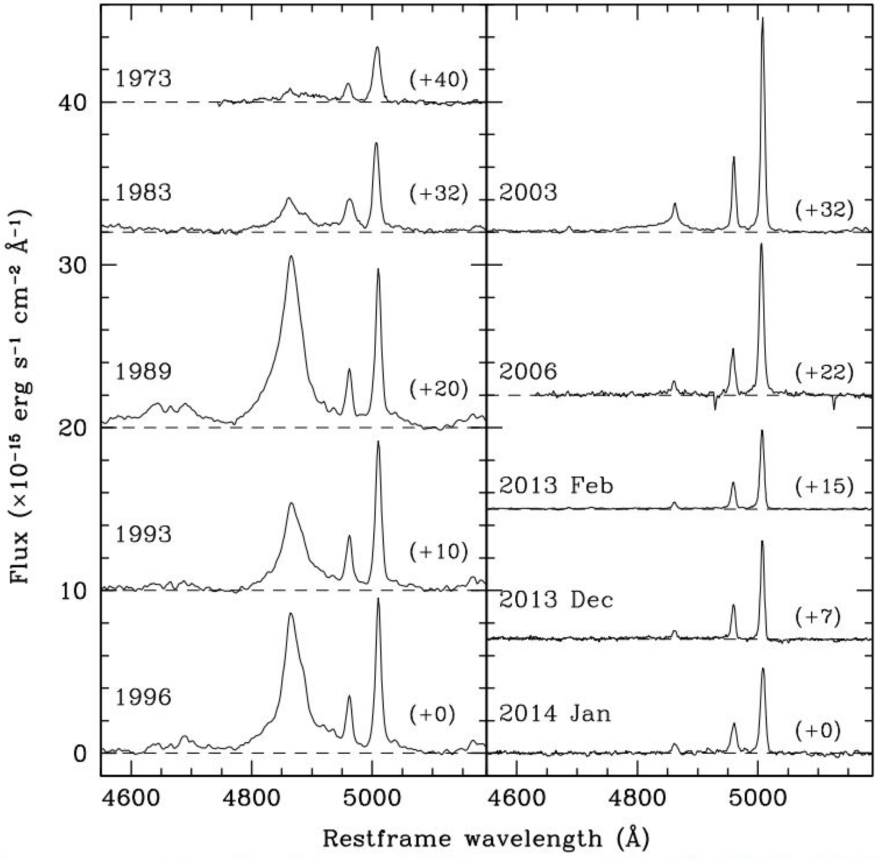
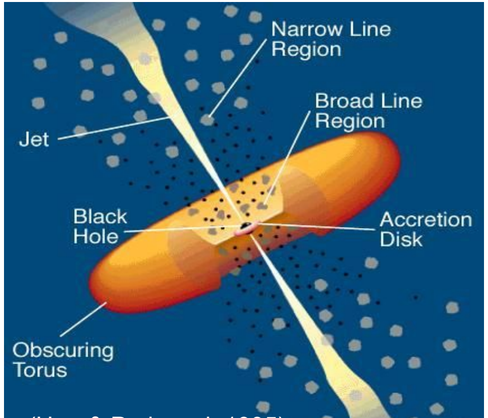
Broad component of Balmer lines (dis)appearence



Mrk 590 (Denney et al. 2014)

- ★ In some of the Changing Look AGN (CL AGN), a broad line disappears
- ★ In others, a broad line appears
- ★ **rarely: recurring (dis)appearance!**

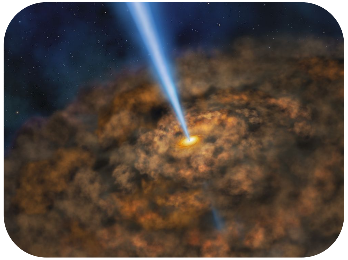


(Urry & Padovani, 1995)

Possible scenarios

Variation of obscuration
(Extrinsic)

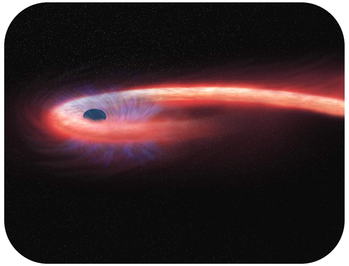
Inconsistent with broad line dimming and timescales



Credit: NASA/SOFIA/Lynette Cook

Tidal disruption event
(Intrinsic)

The flares are longer-lived than the typical TDE



Credit: NASA / CXC / M. Weiss

Changes in accretion rate
(Intrinsic)

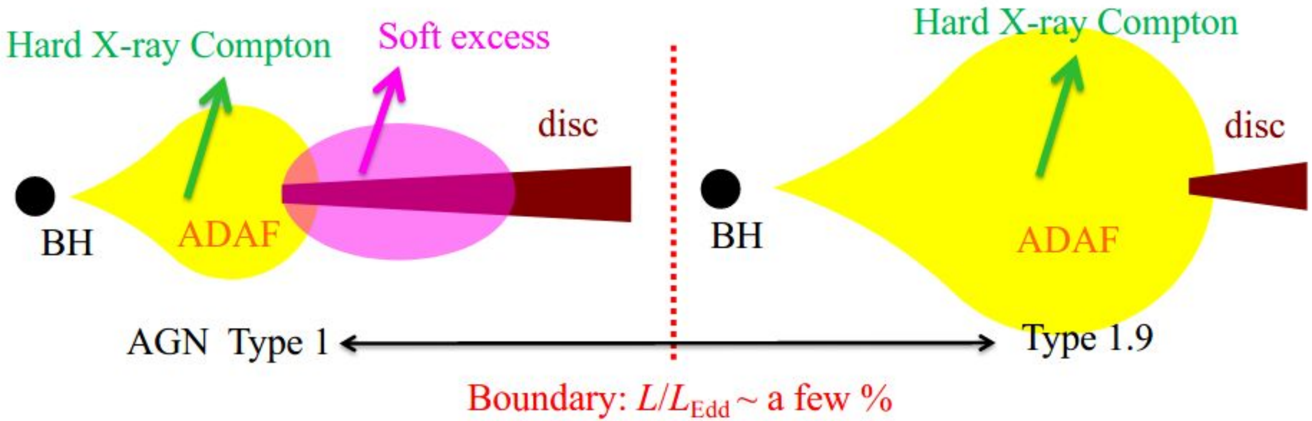
Distinct physical processes from the rest of quasars

Credit: NASA/JPL-Caltech

Intrinsic changes - warm corona

Noda & Done 2018

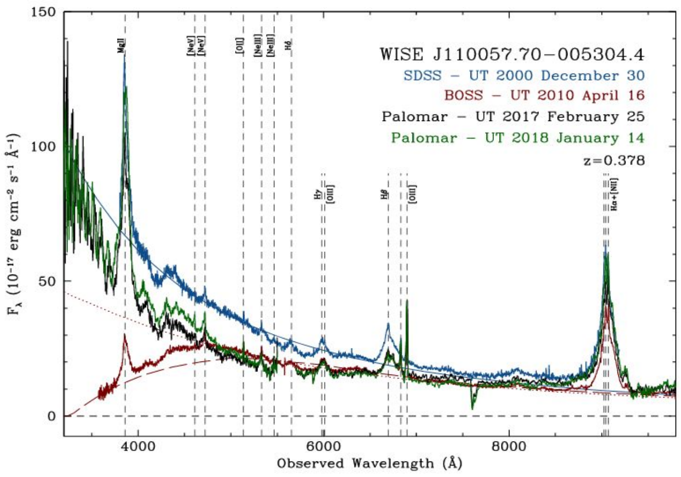
- ★ The CL behaviour in the source Mrk 1018
- ★ Ionisation instability
- ★ NGC 1566: no warm corona before the outburst (Parker et al.19)

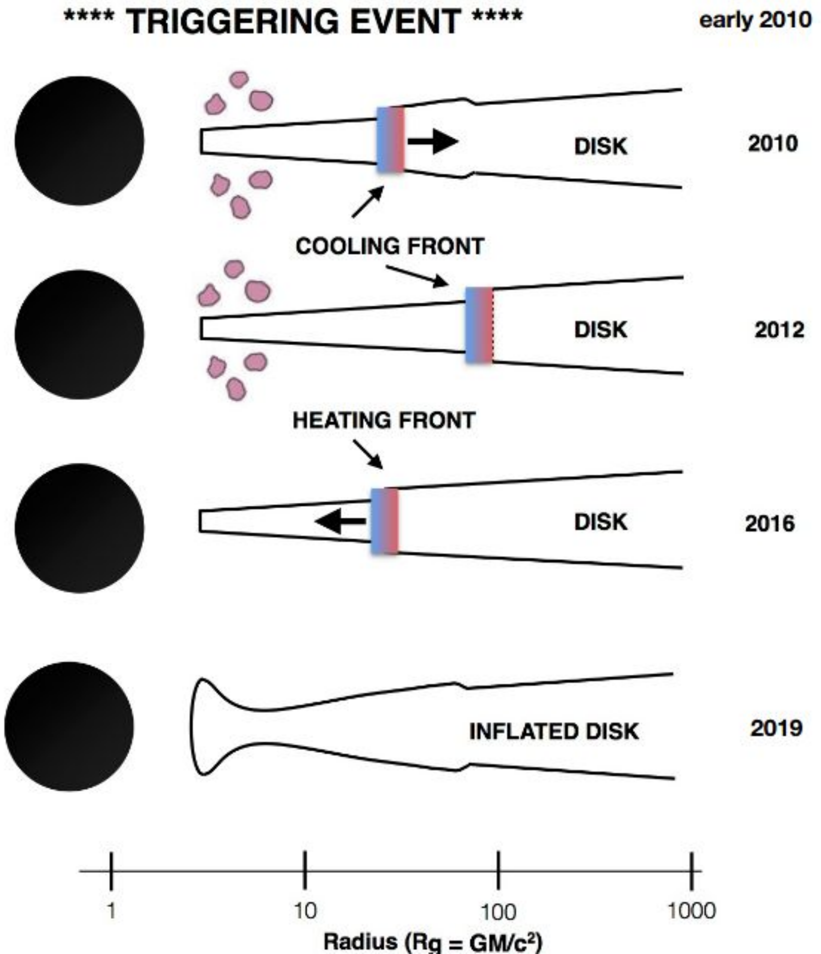


Intrinsic changes - a propagating front

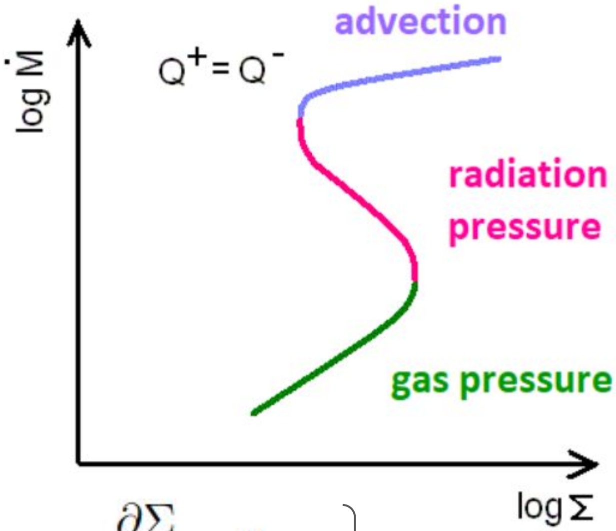
Ross et al. 2018

- ★ Explains the unusual spectral evolution of J1100-0053
- ★ Trigger: change in magnetic field configuration?





Intrinsic changes - Instability of radiation pressure dominated Keplerian disk

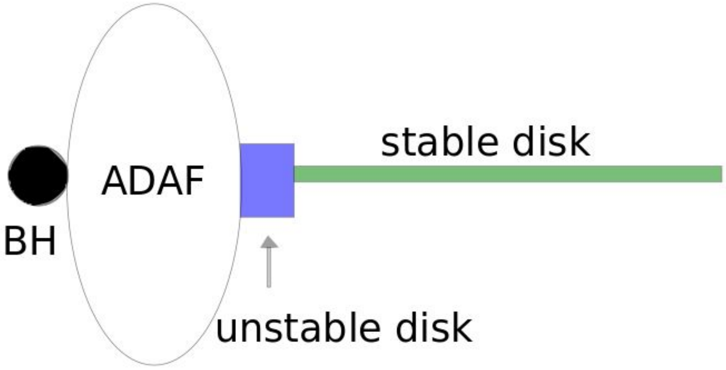


Shakura-Sunyaev disk model:

- ★ the radial momentum equation (Keplerian flow)
- ★ azimuthal one (radial transport of angular momentum)
- ★ vertical one (hydrostatic balance)
- ★ continuity equation (mass conservation)
- ★ energy equation (local balance)
- ★ equation of state

$$\left.\begin{aligned}\frac{\partial \Sigma}{\partial t} &= 0 \\ \frac{\partial T}{\partial t} &= 0\end{aligned}\right\} \longleftarrow \text{stationary solution}$$

A possible mechanism for **multiple** CL events in Active Galactic Nuclei *(Śniegowska et al. 2020)*



- ★ a 3-component, computational toy model
- ★ followed the time-dependent evolution of a single zone
- ★ Viscous timescales scale with ΔR/R

$$\tau_{vis} = \tau_{visSS} \Delta R/R$$

Our model

★ The model is sensitive to the adopted parameters

★ The zone structure may be easily affected by local phenomena

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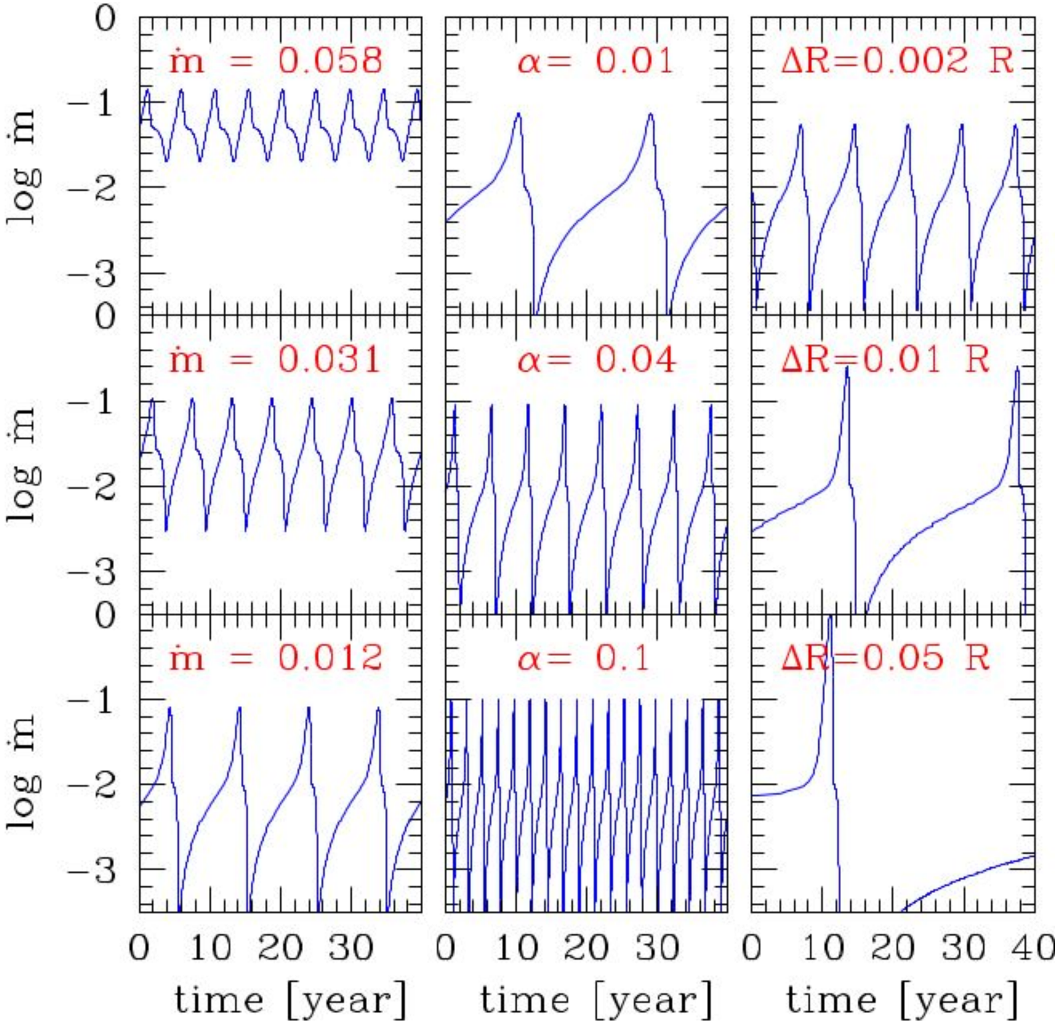
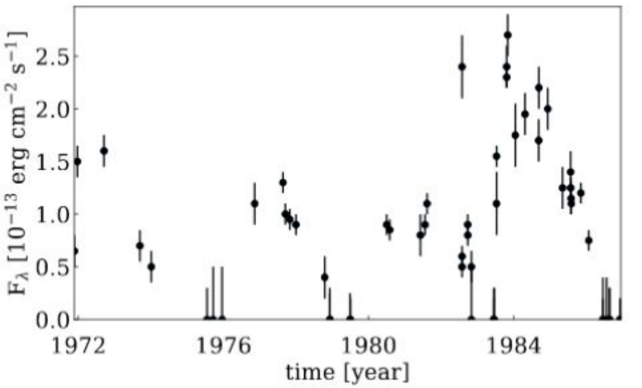
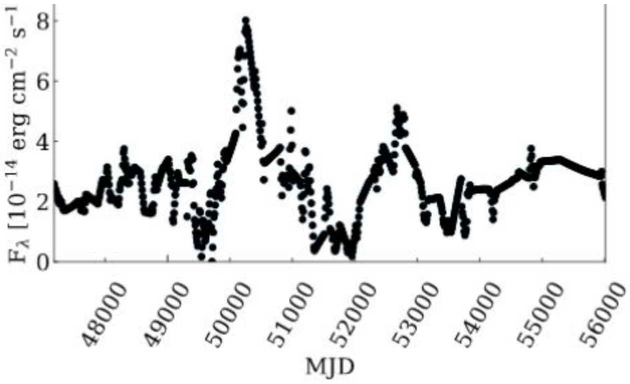
Default parameters:
m=0.0122,
α=0.02,
ΔR=0.003R.

Fixed parameters:
log(M)=6.92 (like in NGC 1566),
R_{in}=30 R_S



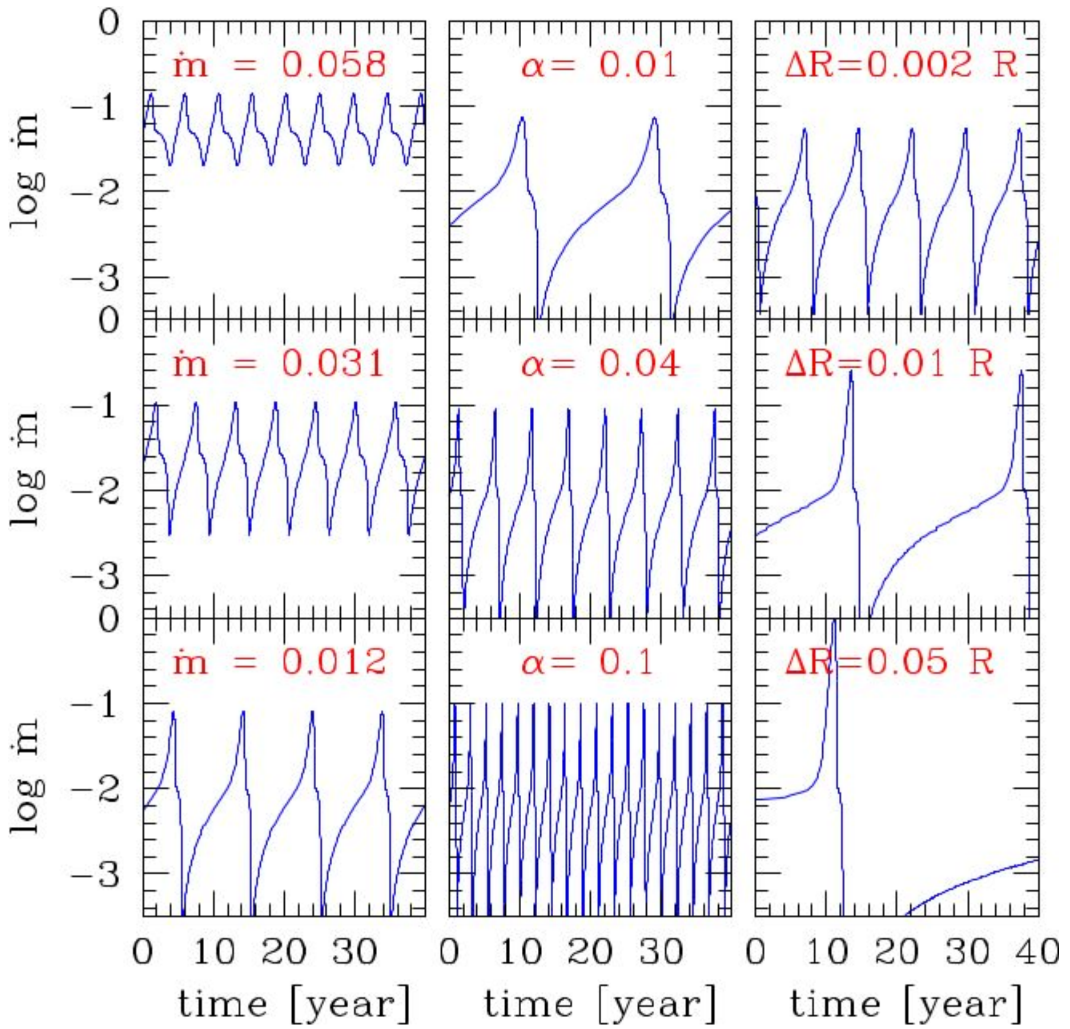


Hβ line flux evolution in NGC 1566 from Alloin et al. (1986).



Continuum flux evolution in NGC 4151 points.

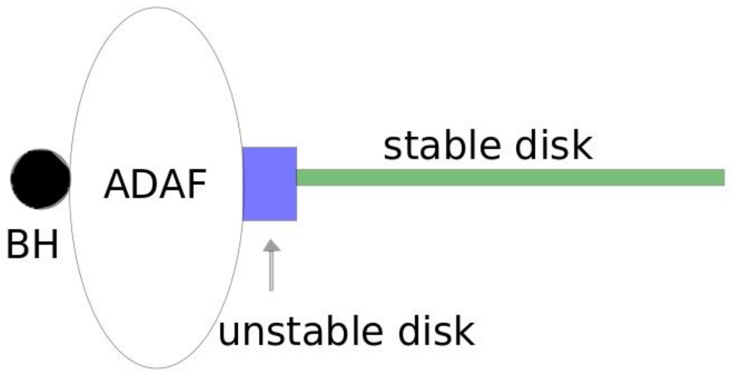
(Śniegowska et al. 2020)



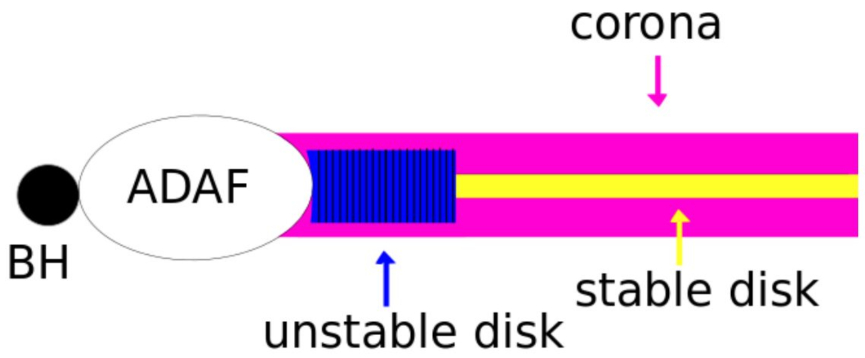
Let's try something more realistic...

GLADIS: GLobal Accretion Disk Instability Simulation Code (Janiuk 2019)

(Śniegowska et al. 2020)

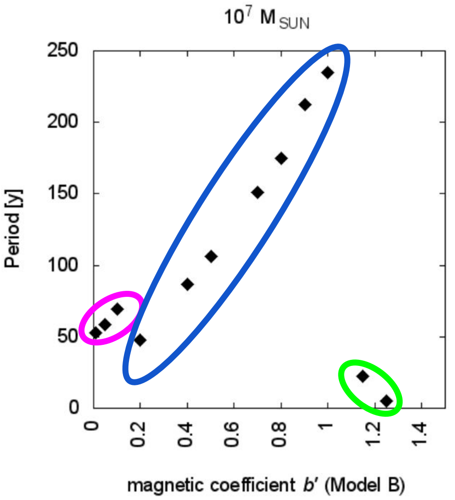


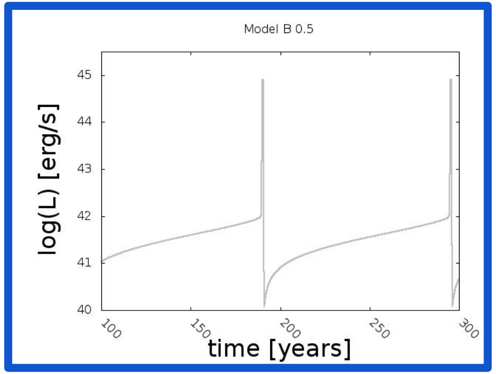
(Śniegowska et al. 2023)



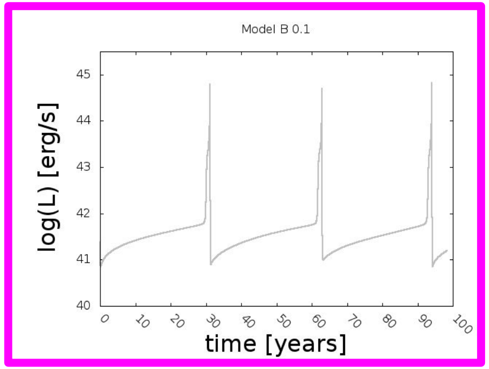
Timescales in Grzędzielski et al. 2017 for M = 10^7 M_{sun} are ~1000s years.
With reduced R_{OUT} = 80 R_S we obtain timescale of 85 years.

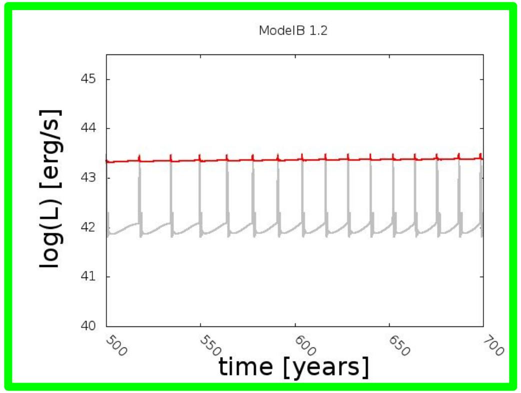
Dependences of the duration of the limit cycle

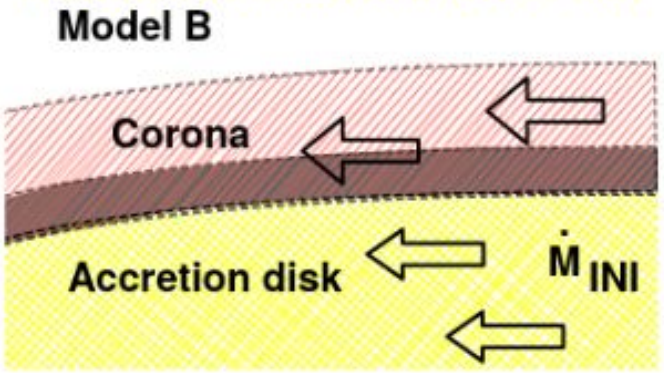




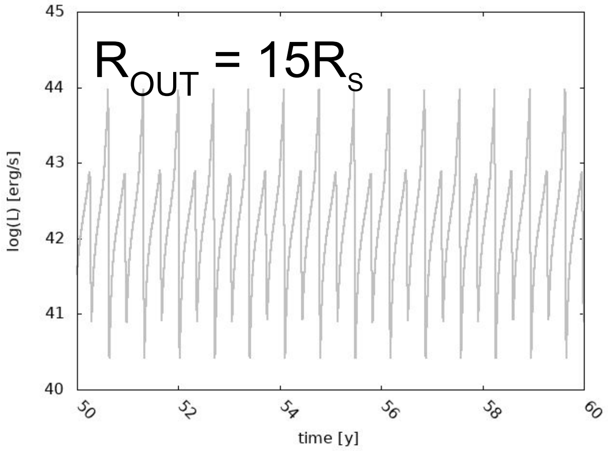
- ★ $\log(M) = 7$
- ★ $\alpha = 0.01$
- ★ $R_{IN} = 3R_S$
- ★ R_{OUT} = **$100R_s$**

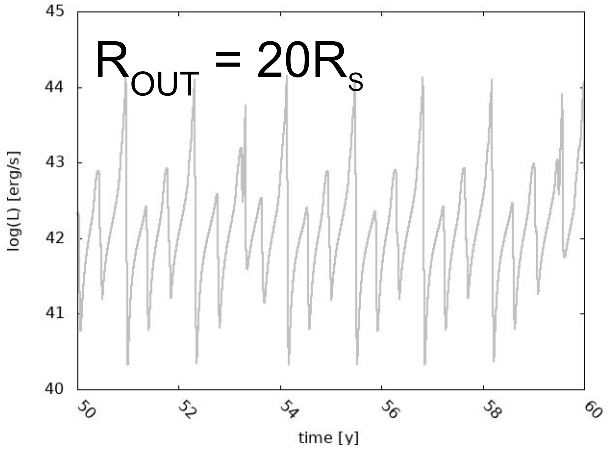


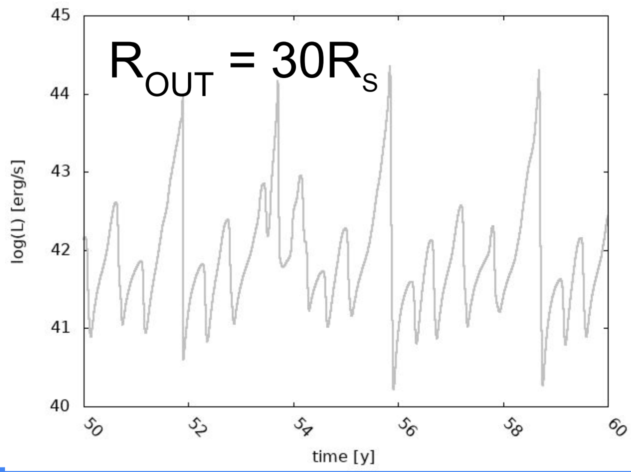


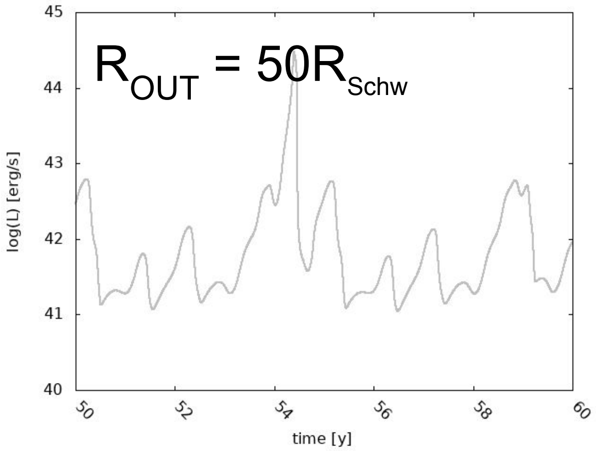


Examples of the light curves with small R_{OUT}









★ $\log(M) = 7$
★ $\alpha = 0.01$
★ $R_{IN} = 3R_S$

Summary

- ★ Many CL AGN have been detected recently
- ★ Large amplitude, long-term QSO variability with follow-up spectroscopy gives us new insights into accretion physics
- ★ Rapid change of accretion rate with time scales of years in the innermost part of accretion disks is preferred for CL AGN
- ★ Possible mechanism of CL AGN is radiation pressure instability, but we need small R_{OUT} and presence of magnetic field
- ★ Next steps:
  - Effect of time evolution of external rate
  - Dynamically expanding outer radius

Thank you!