Interplay between SED and spectral line profiles in the context of gappy accretion discs

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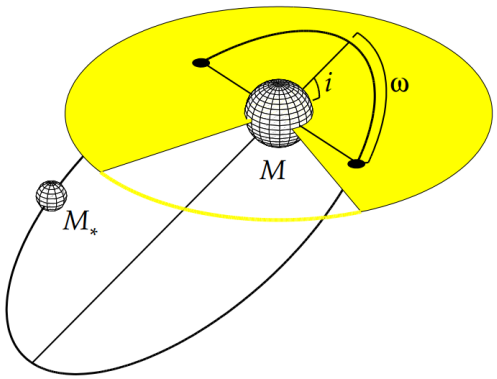
Talk plan

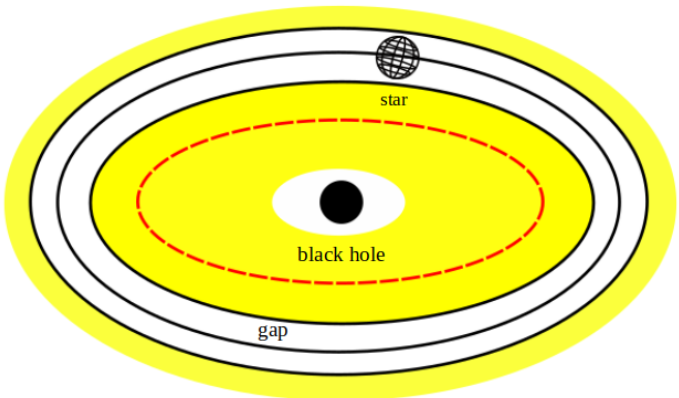
- Initial setup
  - secondary component – star
- Final setup
  - ADAF
  - secondary component – black hole
  - both
- Summary
- Future prospects and possible alternatives

Initial setup



- star in orbital plane of the disc (Karas et al., 2001)
  - $R_{\text{influence of }*} > H$ a gap is created,
  - $R_{\text{influence of }*} < H$ no gap is created, density waves

- stochastic perturbations of stellar motions – star gravitationally bound to the central body
- repetitive satellite (star) - disc interactions (Šubr et al., 1999)
- inclination $\rightarrow 0$ & circularisation of trajectory



Final setup

- in context of SED simulations we introduce
  - model A - ADAF component
  - model B - secondary black hole component
  - model C - ADAF component + secondary black hole component
- model A – gap size (truncated disc from inside out) (e.g. Abramowicz et al., 1995; Kato Nakamura 1998)

$$R_{\mathrm{ADAF}} = 4\alpha^4 \dot{m}^{-2} R_{\mathrm{g}}.$$

- model B, C – gap size given by $2\times$ Hill radius (temperature profile $T(R)$ is cut off in the are of the gap!)

$$\approx \frac{2d}{R_{\mathrm{g}}} \left(\frac{M_2}{3M_1} \right)^{1/3}$$

- in context of spectral line profiles we only introduce model A, C

Assumptions

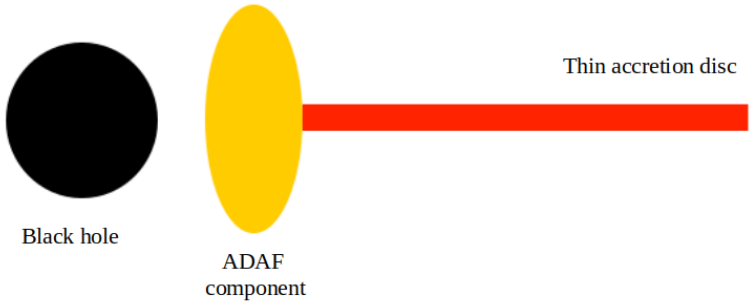
- parameters:
  - inclination i
  - primary (central) black hole M_1
  - secondary black hole M_2 (if present)
  - accretion rate $\dot{M}_\bullet = \dot{m}\, M_{\rm Edd}$
  - primary (central) and secondary black hole distance d
- in our simulations we set $M_1 = 10^9\, M_\odot$, $M_2 = 10^{-2}\, M_1$ (if present), $i = 35\,\mathrm{deg}$
- model B, C – we neglect $M_2 = 10^{-1} M_1$ (both orbiting centre of gravity), $M_2 = 10^{-3} M_1$ (negligible changes in spectra)
- stable gap trail

$$\frac{t_{\rm vis}}{T_{\rm orbit}} = \frac{R^2}{H^2}\frac{1}{2\alpha\pi} \gg 1$$

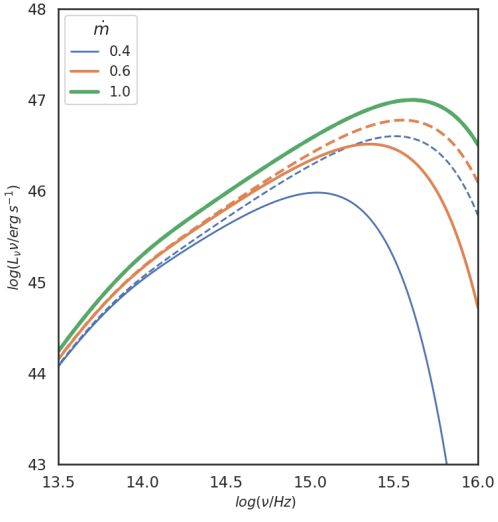
- model B, C – we accept distances that lead to $t_{\rm merge} > 10^4 yr$

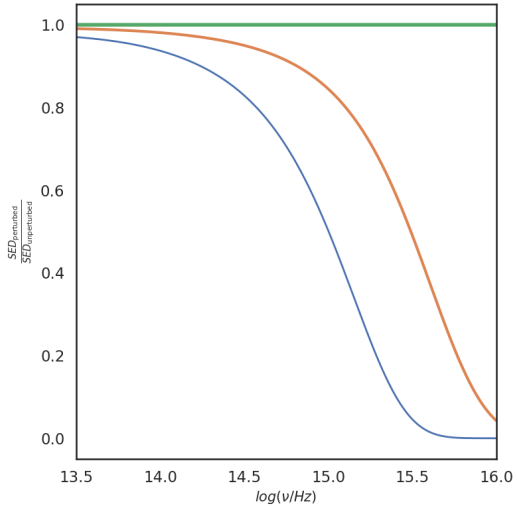
SED model A

- $\dot{m} = 0.4 \rightarrow R_{\mathrm{ADAF}} = 25 R_{\mathrm{g}}$
- $\dot{m} = 0.6 \rightarrow R_{\mathrm{ADAF}} = 11 R_{\mathrm{g}}$
- $\dot{m} = 1.0 \rightarrow R_{\mathrm{ADAF}} = 4 R_{\mathrm{g}}$



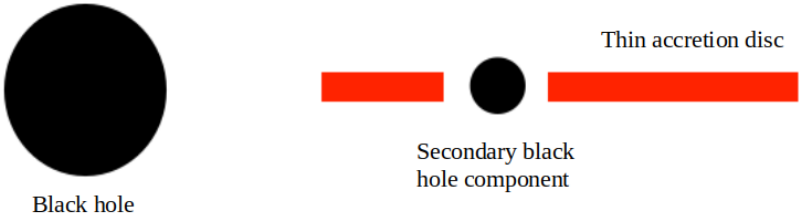
Model A



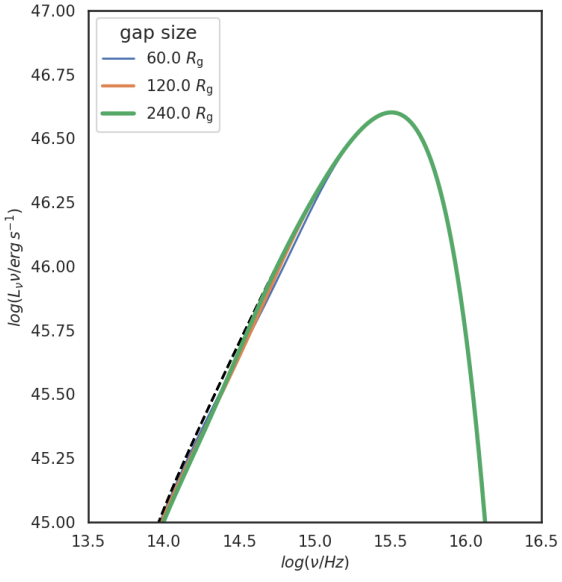


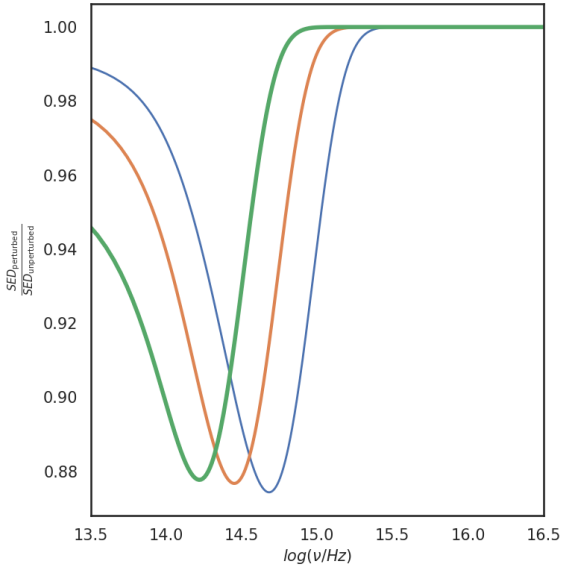
SED model B

- $d = 200 R_{\rm g} \rightarrow \text{gap size} = 60 \mathrm{R_g}$
- $d = 400 R_{\rm g} \rightarrow \text{gap size} = 120 \mathrm{R_g}$
- $d = 800 R_{\rm g} \rightarrow \text{gap size} = 240 \mathrm{R_g}$



Model B

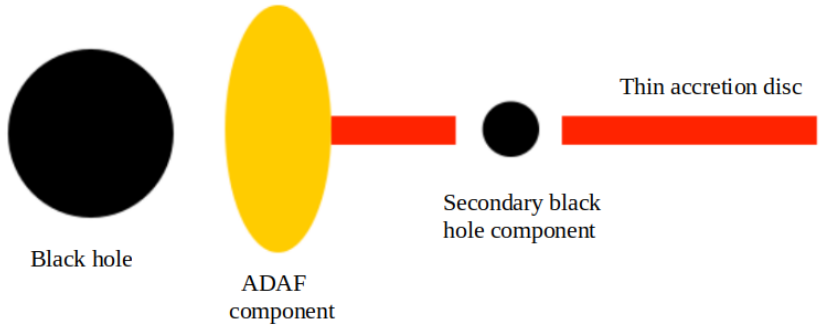




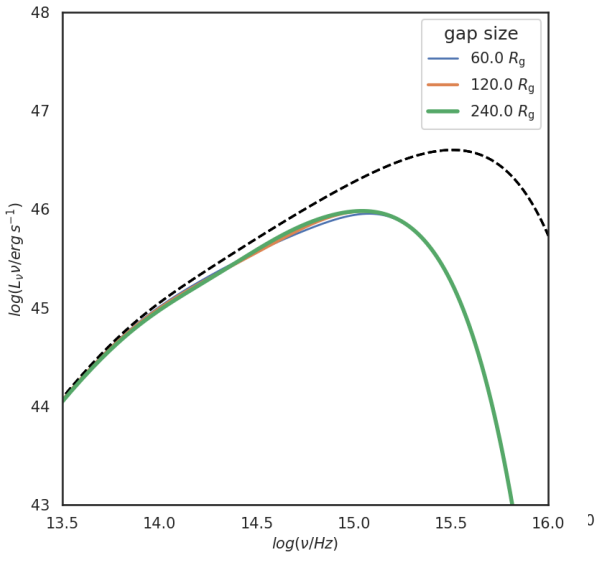
SED model C

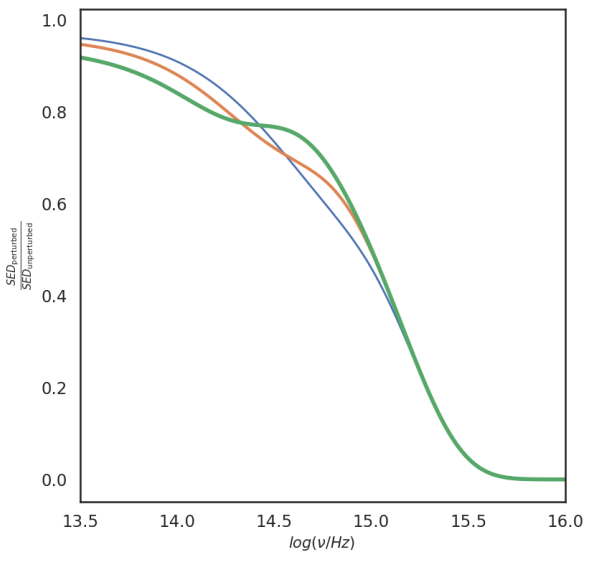
- $d = 200 R_{\rm g} \rightarrow \text{gap size} = 60 \mathrm{R_g}$
- $d = 400 R_{\rm g} \rightarrow \text{gap size} = 120 \mathrm{R_g}$
- $d = 800 R_{\rm g} \rightarrow \text{gap size} = 240 \mathrm{R_g}$

$\dot{m} = 0.4 \rightarrow R_{\rm ADAF} = 25 R_{\rm g}$



Model C

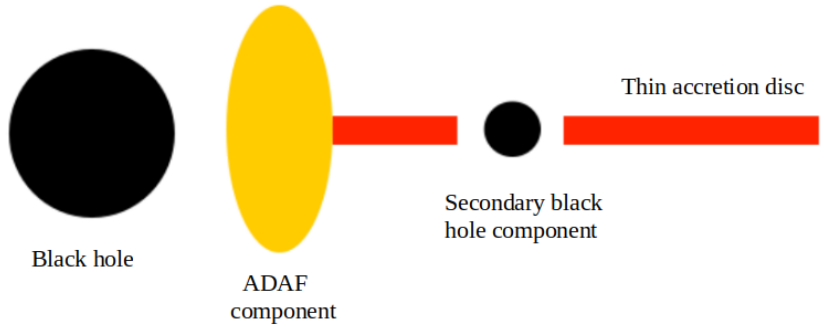




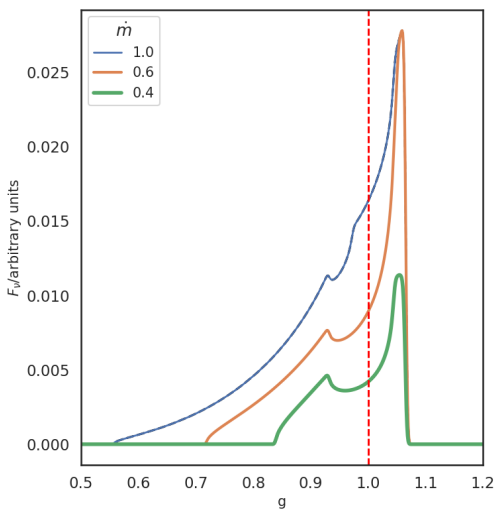
Spectral line model A, C

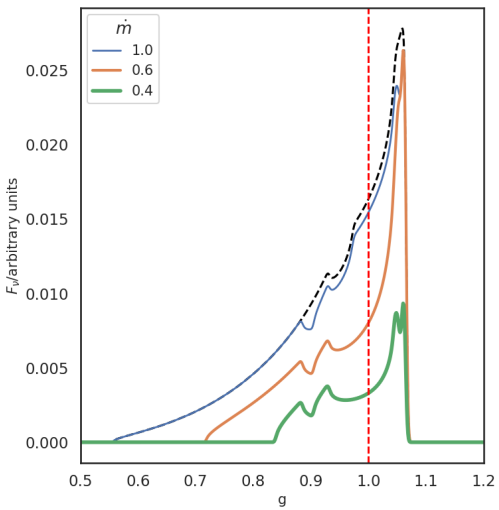
- $\dot{m} = 0.4 \rightarrow R_{\mathrm{ADAF}} = 25 R_{\mathrm{g}}$
- $\dot{m} = 0.6 \rightarrow R_{\mathrm{ADAF}} = 11 R_{\mathrm{g}}$
- $\dot{m} = 1.0 \rightarrow R_{\mathrm{ADAF}} = 4 R_{\mathrm{g}}$

$d = 50 R_{\mathrm{g}} \rightarrow \mathrm{gap\,size} = 15 \mathrm{R_g}$



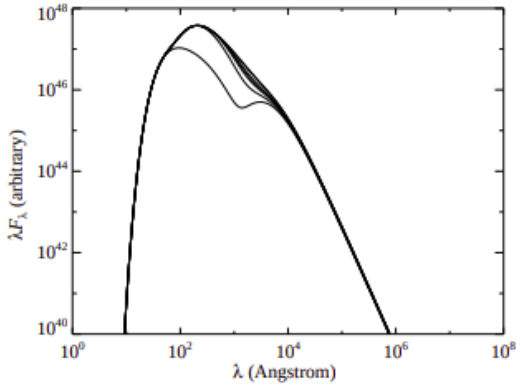
Model A, C





Summary

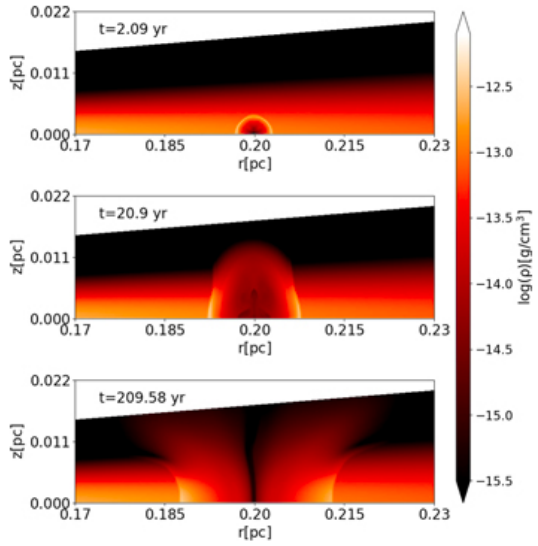
- model A simulations are equivalent to truncated disc SED, good observational prognosis
- star with 100 $M_\odot \sim 0.003 dR_\mathrm{g}$, model B simulations still show $\approx 12\%$ difference between the perturbed and unperturbed SED
- possible overlapping of ADAF region and secondary gap in model C for sources with low accretion rate
- for the model B to be used for the observed data the gap has to reach below 100 R_g – in agreement with Gültekin et al., 2012
- rippled spectral line profile behaviour (flux decrease, doubled number of peaks) – in agreement with McKernan et al., 2013

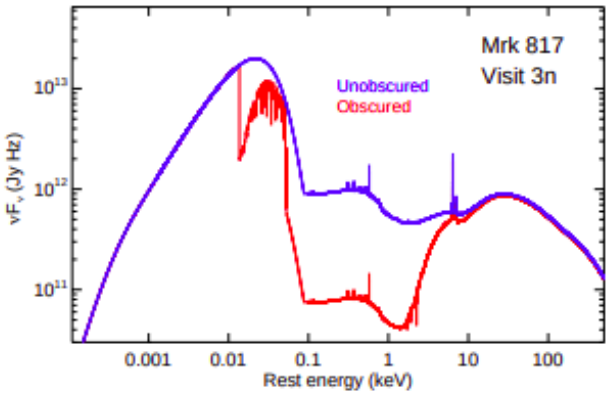


Gültekin et al., 2012

Future prospects and possible alternatives

- TDE destruction of corona (e.g. Ricci et al., 2020)
- supernova explosion – sweeping large parts of accretion disc (e.g. Moranchel-Basurto et al., 2020)
- clouds obscuring the vision can act as a perturber as well (e.g. Kara et al., 2021)
- triple merger – the gap position not arbitrary
- Athena – more sensitive data





Moranchel-Basurto et al., 2020 (left panel); Kara et al., 2021 (right panel)