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

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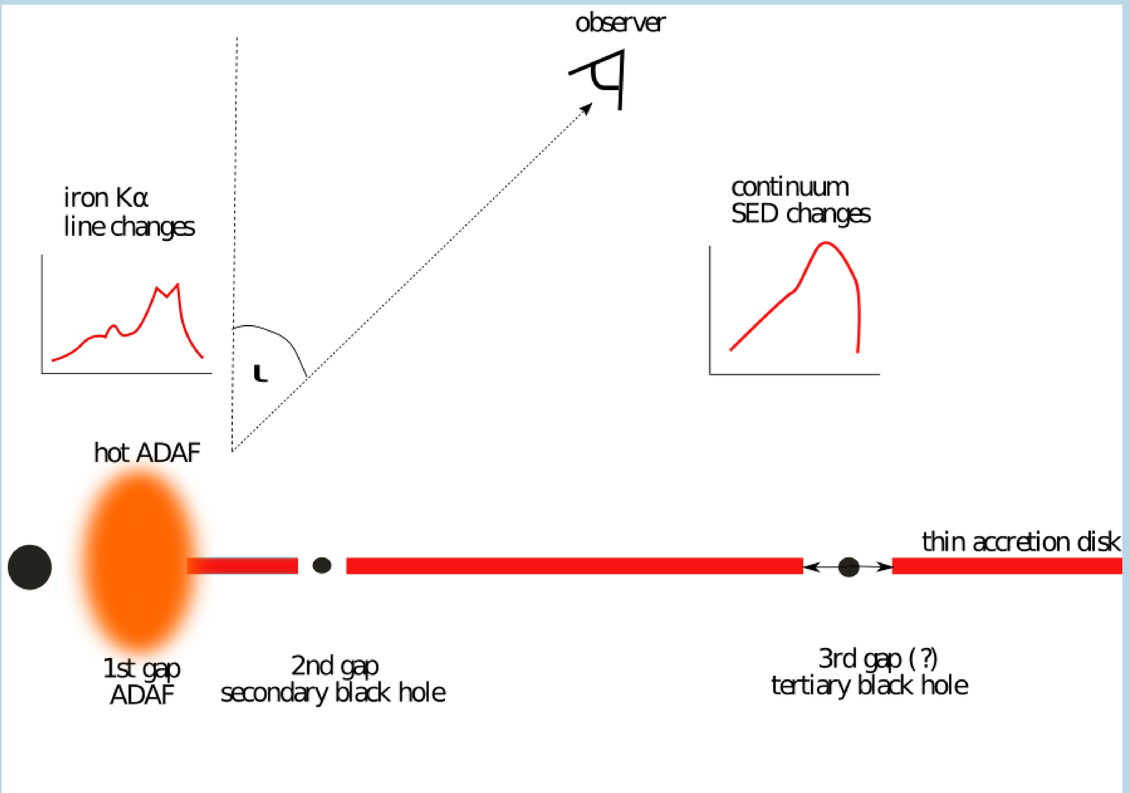
Problem

We study the perturbations in the accretion disc and the emerging SED and spectral line changes caused by the presence of either

- an inner optically thin, radiatively inefficient hot flow – ADAF component;
- a secondary black hole component embedded within the accretion disc;
- a combination of both components.



Basic Concepts & Contiditons

ADAF component represents the central cavity (truncated disc from inside out) with $R_{\rm ADAF} = 4\alpha^4 \dot{m}^{-2} R_{\rm g}$.

Secondary black hole component represents the outer gap width given by $2\times$ Hill radius $\approx \frac{2d}{R_{\rm g}} \left(\frac{M_2}{3M_1}\right)^{1/3}$.

To assess the gap **trail stability** we assume $\frac{t_{\rm vis}}{T_{\rm orbit}} \frac{R^2}{H^2} \frac{1}{2\alpha\pi} \gg 1$.

Specifically for the SED cases we accept the scenarios with $\mathbf{t_{merge} > 10^4 yr}$.

The free parameters of the multi-gap model are: inclination i, mass of the primary Schwarzschild black hole M_1, the accretion rate of the primary black hole $\dot{M}_\bullet = \dot{m} M_{\rm Edd}$, mass of the secondary black hole M_2 and the distance between the primary and the secondary black hole d. Parameters M_2, and d apply only in case of the presence of the secondary component in the system. The inner gap is set uniquely by M_1 and $\dot{m}$, unless stated otherwise.

Models

We present the following models

- **model A** – ADAF component;
- **model B** – secondary black hole component;
- **model C** – ADAF component + secondary black hole component.

We focus on SED changes in context of model A, B and C. In case of spectral line profile changes we take into account only model A and C.

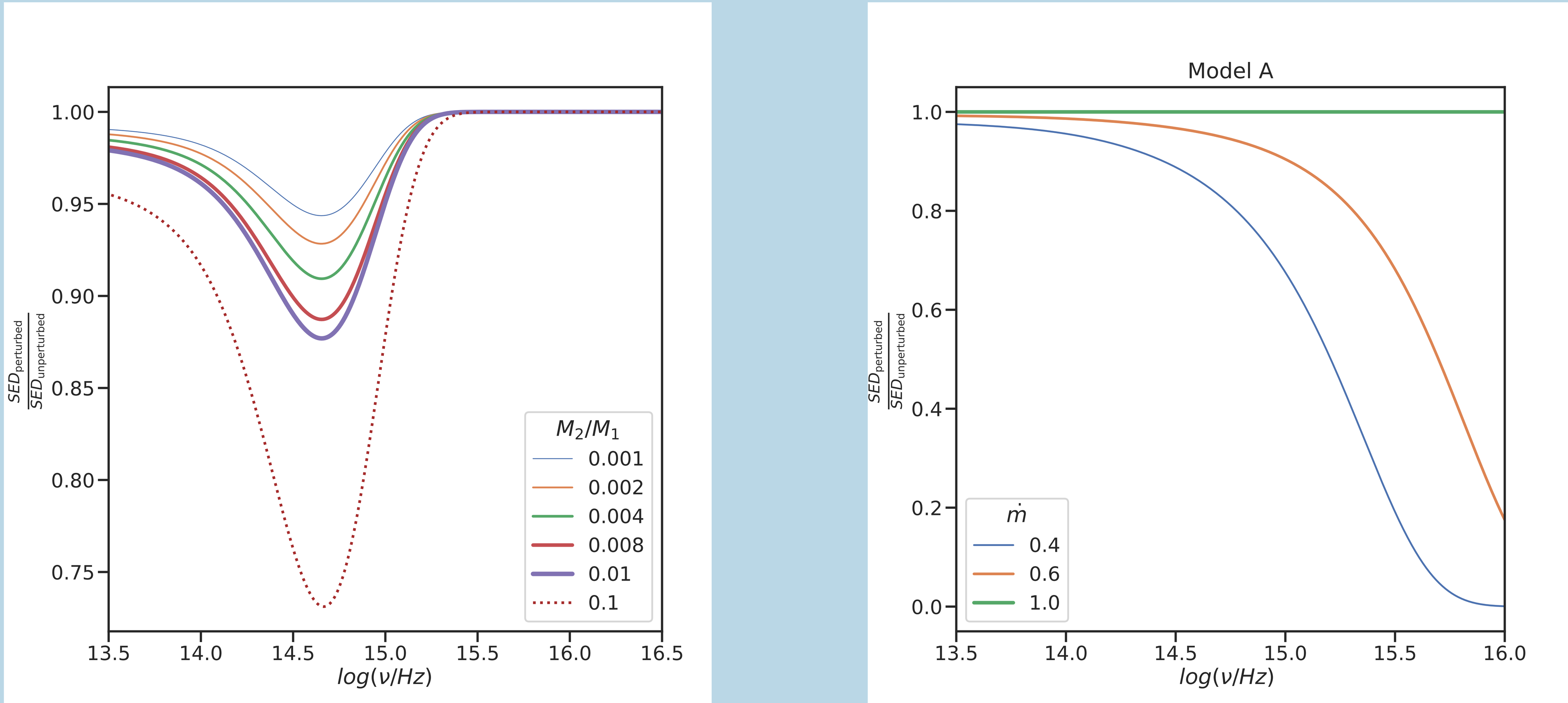
Conclusions

- We simulate data with decreased flux based on the perturber distance (both SEDs and spectral line profiles) and doubled amount of peaks (spectral line profiles).
- We are able to constrain the size of the central cavity with synthetic data assuming errors up to 10% (SEDs – model A).
- We are able to recover the outer gap width with synthetic data assuming errors up to 2% (SEDs – model B).
- We realize SEDs and spectral line profiles to be the tracing tools for both, inner and outer, and inner region, respectively.

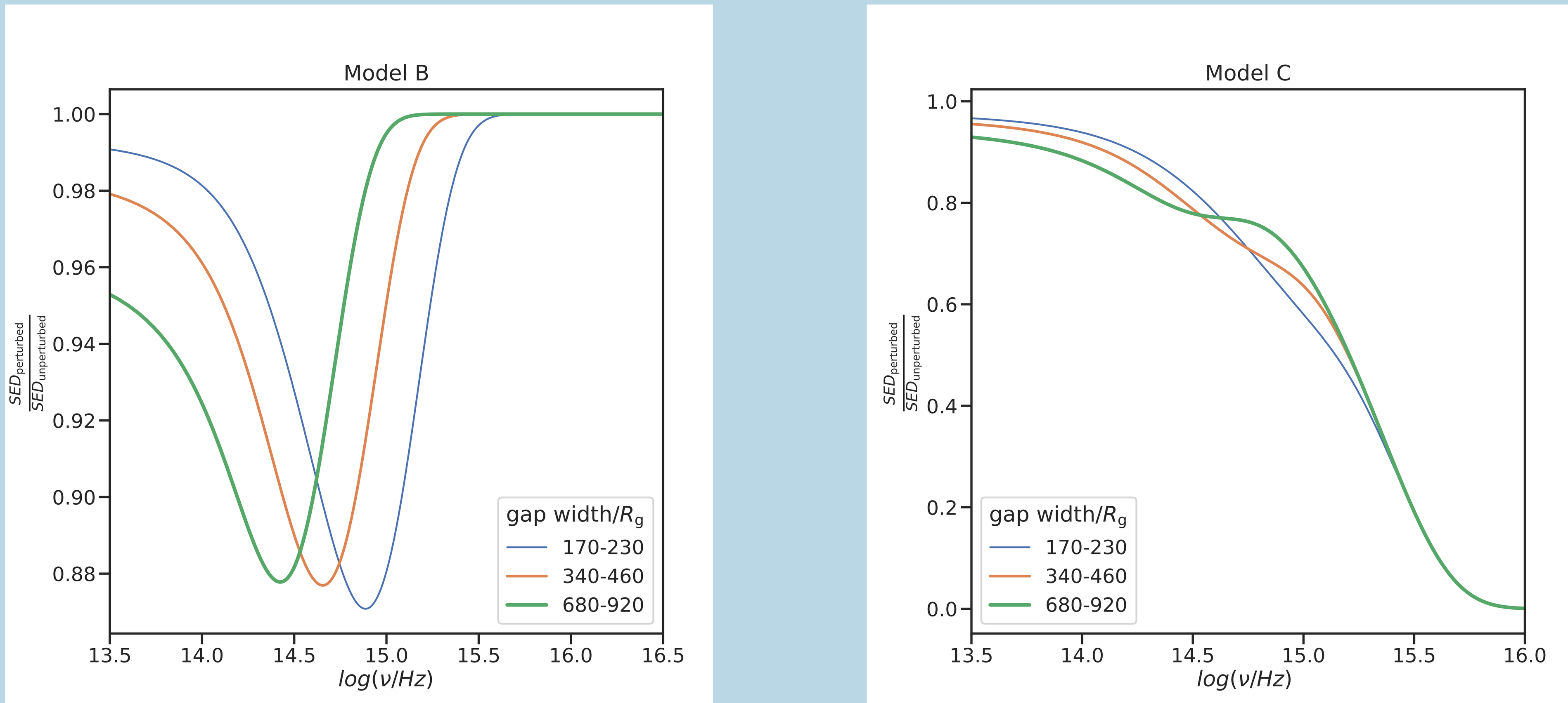
Abstract

Both spectral energy distribution (SED) of the continuum and the spectral lines offer a way to measure and model parameters of the inner and outer region of the black hole accretion disc. We introduce a perturbative term located in the orbital plane of the accretion disc and parametrize the spectral changes to reveal the decrease of the emissivity of the expected signal. We assume three different scenarios (i) an inner optically hot flow component; (ii) a secondary black hole component; or (iii) a combination of both. We address the qualitative differences of the spectral features with respect to the standard disc-line scenario and discuss the conditions and methods used to constrain the parameters of the system.

SEDs

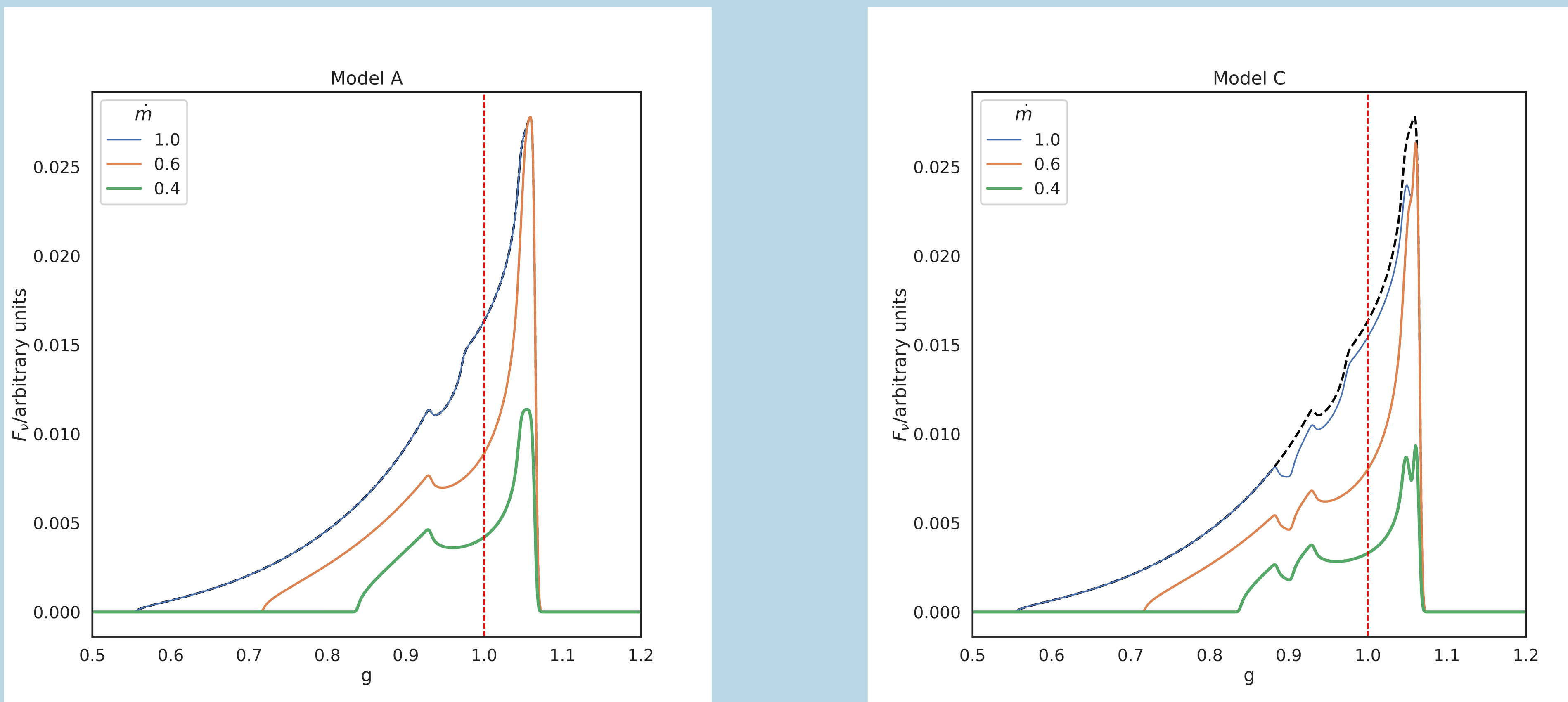


Simulated SED ratios of the perturbed with respect to the unperturbed model from an accretion disc with an outer gap with the perturber located at $400R_{\rm g}$ and the dimensionless accretion rate $\dot{m}$ set to 0.4 (left panel) and with an inner gap (right panel). The inclination angle has been set to 35deg and M_2/M_1 to 0.01, unless stated otherwise. The size of the radiatively contributing unperturbed accretion disc spans from 6 to $5000R_{\rm g}$.



Simulated SED ratios of perturbed with respect to the unperturbed model from an accretion disc with an outer gap (left panel) and the combination of inner and outer gap (right panel), both varying with the perturber's position. The inclination angle has been set to 35deg, M_2/M_1 to 0.01 and the dimensionless accretion rate $\dot{m}$ is 0.4. The size of the radiatively contributing unperturbed accretion disc spans from 6 to $5000R_{\rm g}$.

Spectral line profiles



Simulated spectral line profiles of perturbed and unperturbed (black dashed line) model from an accretion disc with an inner gap (left panel) and the combination of inner and outer gap, with the perturber located at $50R_{\rm g}$ (right panel), both varying the size of the inner gap. The inclination angle has been set to 35deg and M_2/M_1 to 0.01. The size of the radiatively contributing unperturbed accretion disc spans from 6 to $100R_{\rm g}$.