Signatures of reverberation signals in the AGN X-ray power-spectra

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ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ
επένδυση στην κοινωνία της γνώσης
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ ΚΑΙ ΘΡΗΣΚΕΥΜΑΤΩΝ
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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

X-ray illumination of the inner part of the accretion disc around a rotating BH affects the spectral properties (e.g. asymmetric/broad iron lines, soft excess, Compton hump) and timing properties ("reverberation" time-lags) of a source.

In this case:

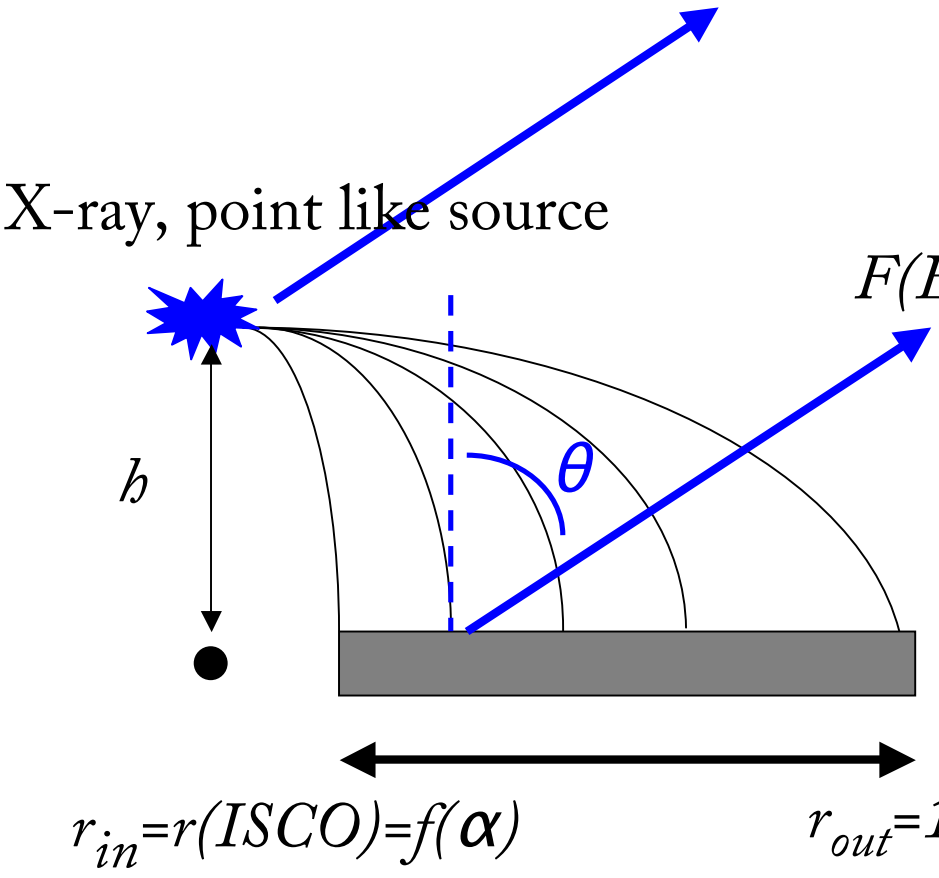
observed flux = primary + reprocessed flux

a filtered "echo" of the primary emission

- ✓The power spectra (PSDs) in energy bands where the reflection component is strong should display features of this echo.
- ✓These features should depend on the characteristics of the system (BH mass, spin, source height, and inclination angle).
- ✓Therefore, PSDs can be used to study reflection just like the study of the iron line shape and of the time-lags.

The model set-up

$$F(E,t)_{primary} = D(E) \times \underbrace{N(t) \times E^{-\Gamma} \exp(-E/300\ \mathrm{keV})}_{F(E,t)_{intrinsic}}$$



$$F(E,t)_{refl} = \int_0^\infty \Psi_E(t-\xi) F(E,t)_{intrinsic} d\xi$$

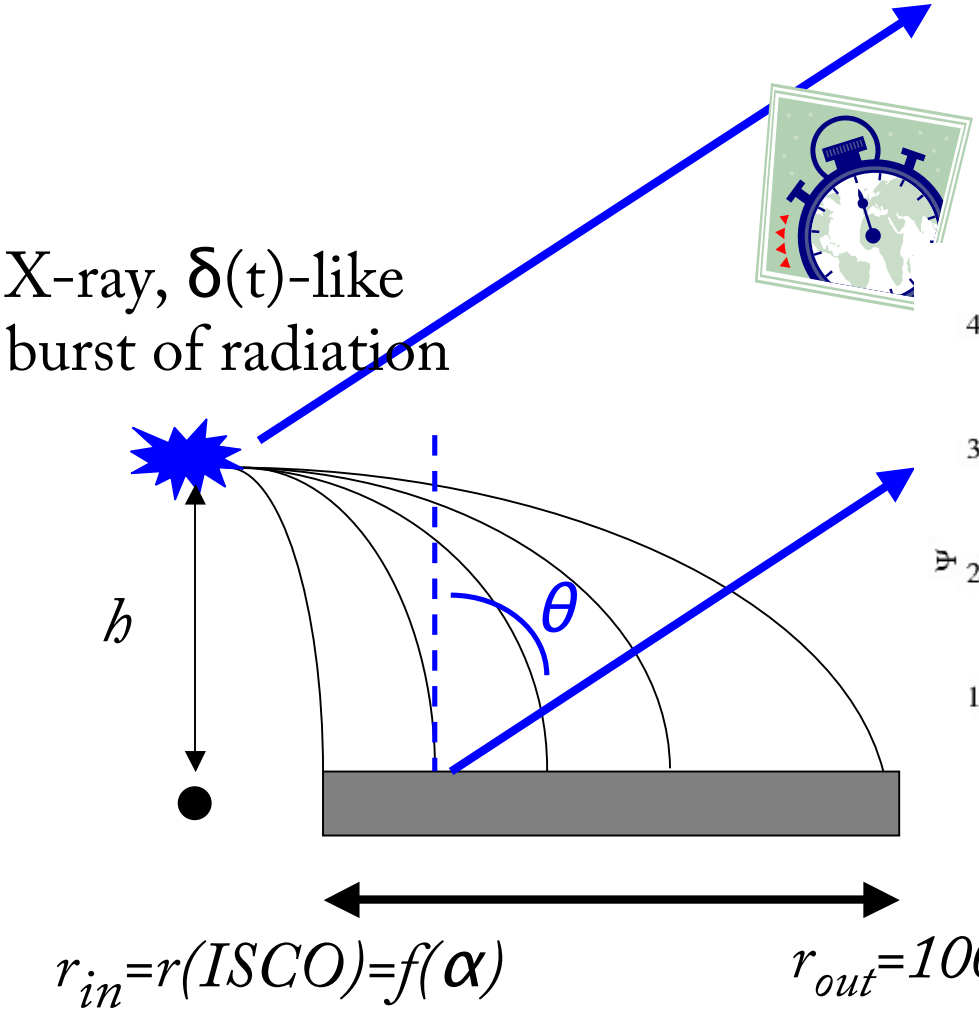
"disc response function"

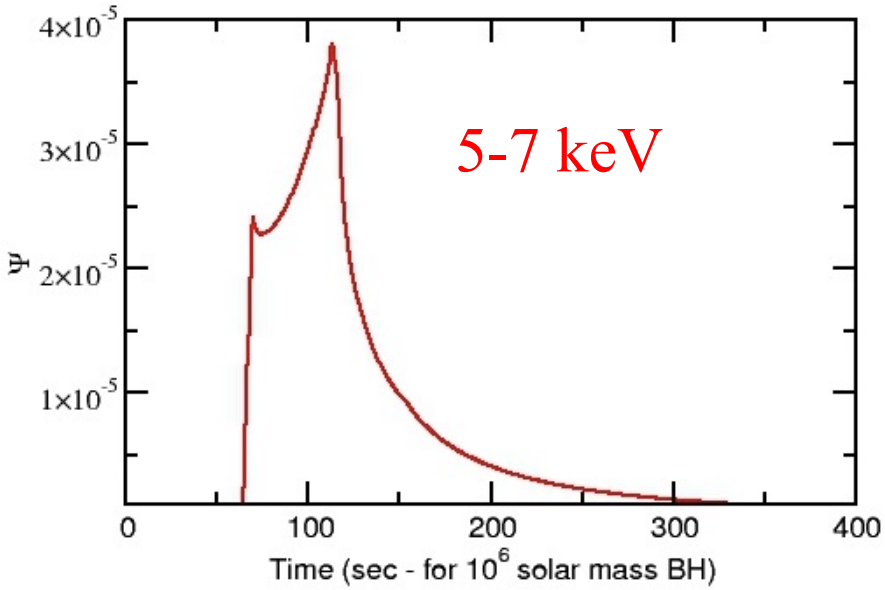
Keplerian disc,
co-rotating with BH

The disc response function for the full reflection spectrum

t_0=0 is the time we detect the primary photons. After some time, we detect the reflection component photons as well.

X-ray, δ(t)-like burst of radiation





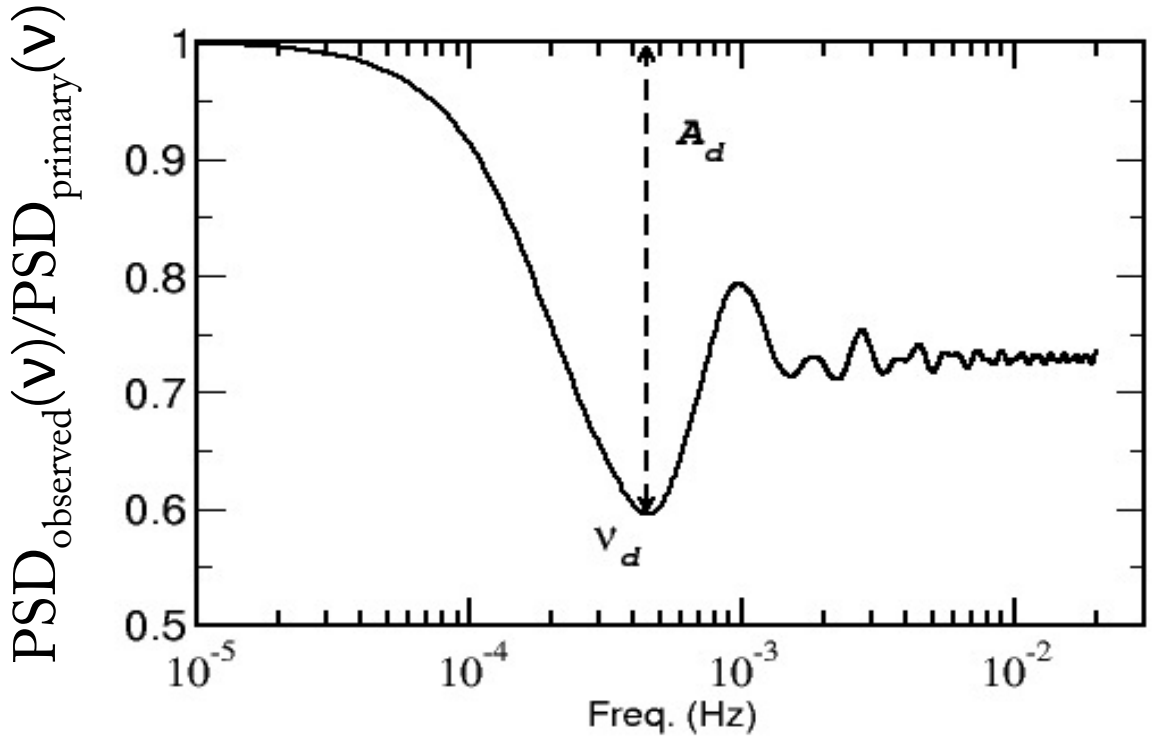
Ψ=*f*(h,r-in,r-out,θ,E)

In this case:

$$F(E,t)_{total,observed} = F(E,t)_{primary} + \underbrace{F(E,t)_{reflection}}_{\text{a delayed and “filtered” version of the continuum}}$$

$$PSD_{total,observed}(\nu) = PSD_{primary}(\nu) \times |\Gamma(E,\nu)|^2$$

Where: $\underbrace{\Gamma(E,\nu) = \int_0^\infty \Psi_E(t-\xi)\exp(-i2\pi\nu\xi)d\xi}_{\text{is the transfer function of the system}}$



5-7 keV

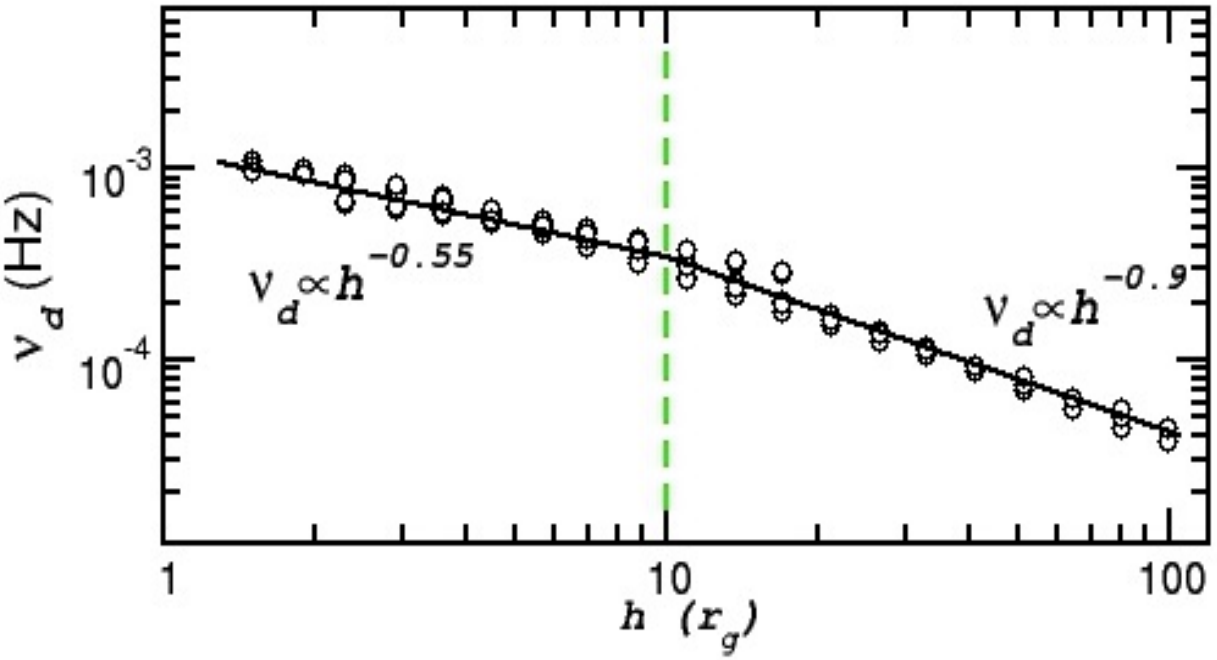
We expect the observed PSDs (in energy bands where the reflection component is expected to be strong) to show an "oscillatory" behaviour (with a decreasing amplitude) at high frequencies.

The amplitude and frequency of the first dip (A_d and ν_d) depend on:

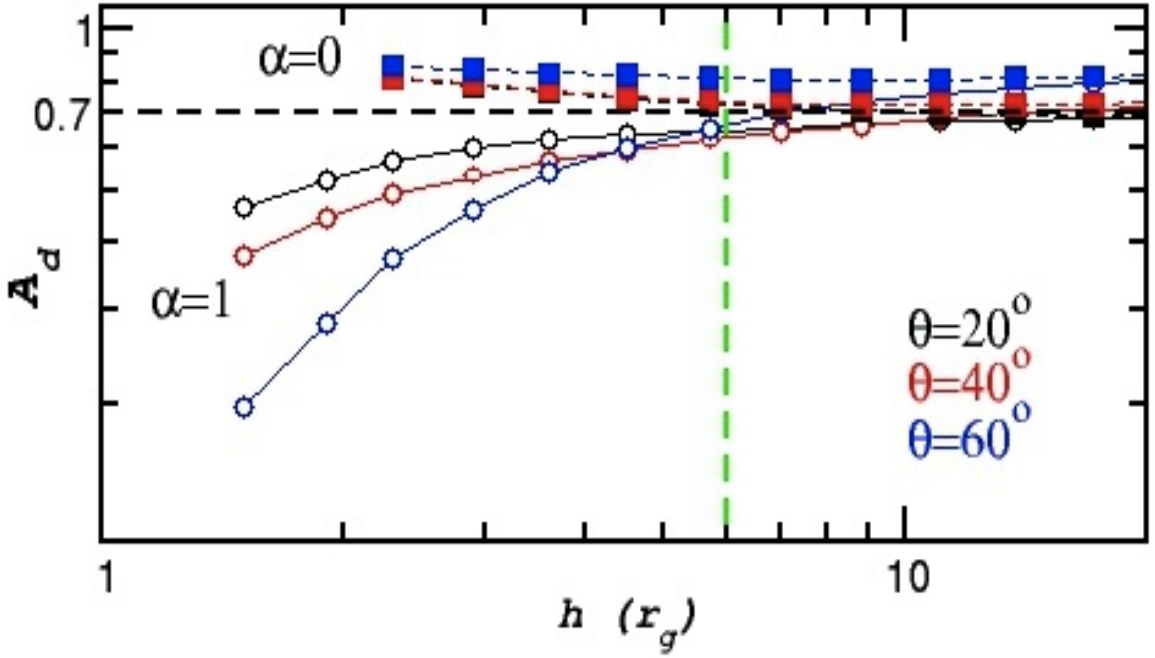
h, $r_{in}(\alpha)$, and θ

(for a given M_{BH}, ionization state of the disc, & iron abundance)

Results for:
5-7 keV PSDs,
in the case of
neutral material &
a 10^7 solar mass BH.

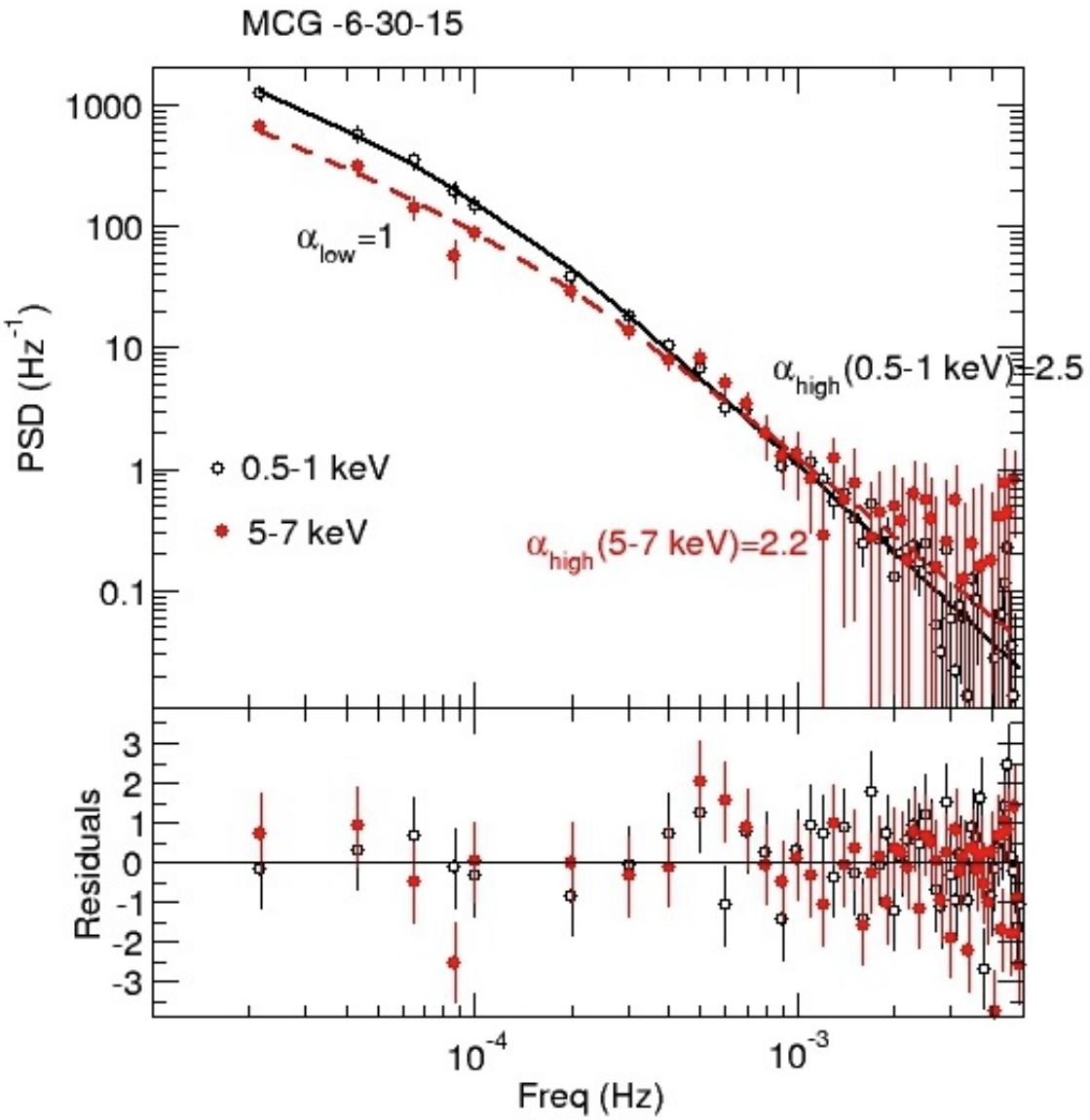


If one can detect the
first "dip" in a PSD,
then one can estimate
h from ν_d, and then,
α and θ from A_d.

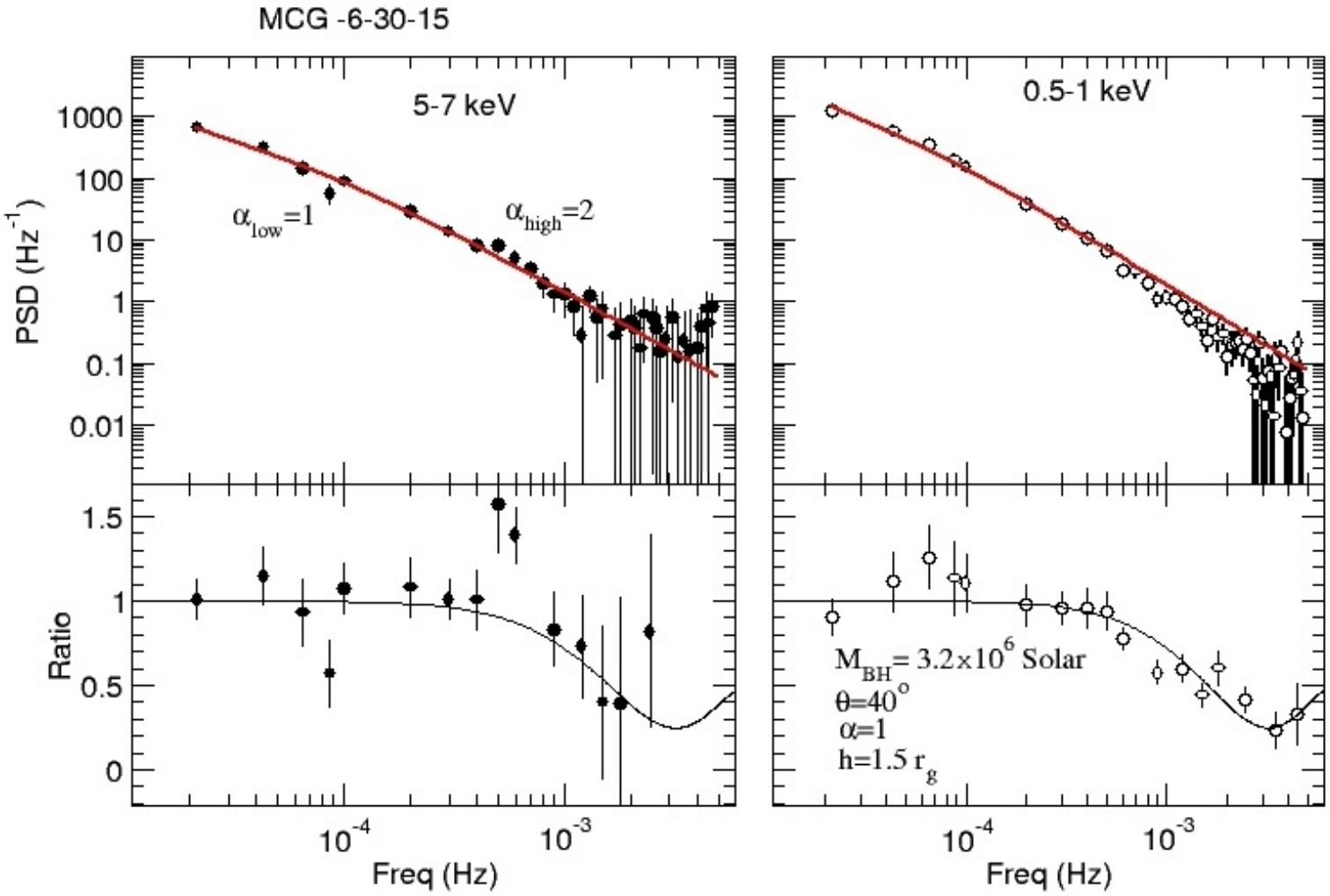


Comparison with data

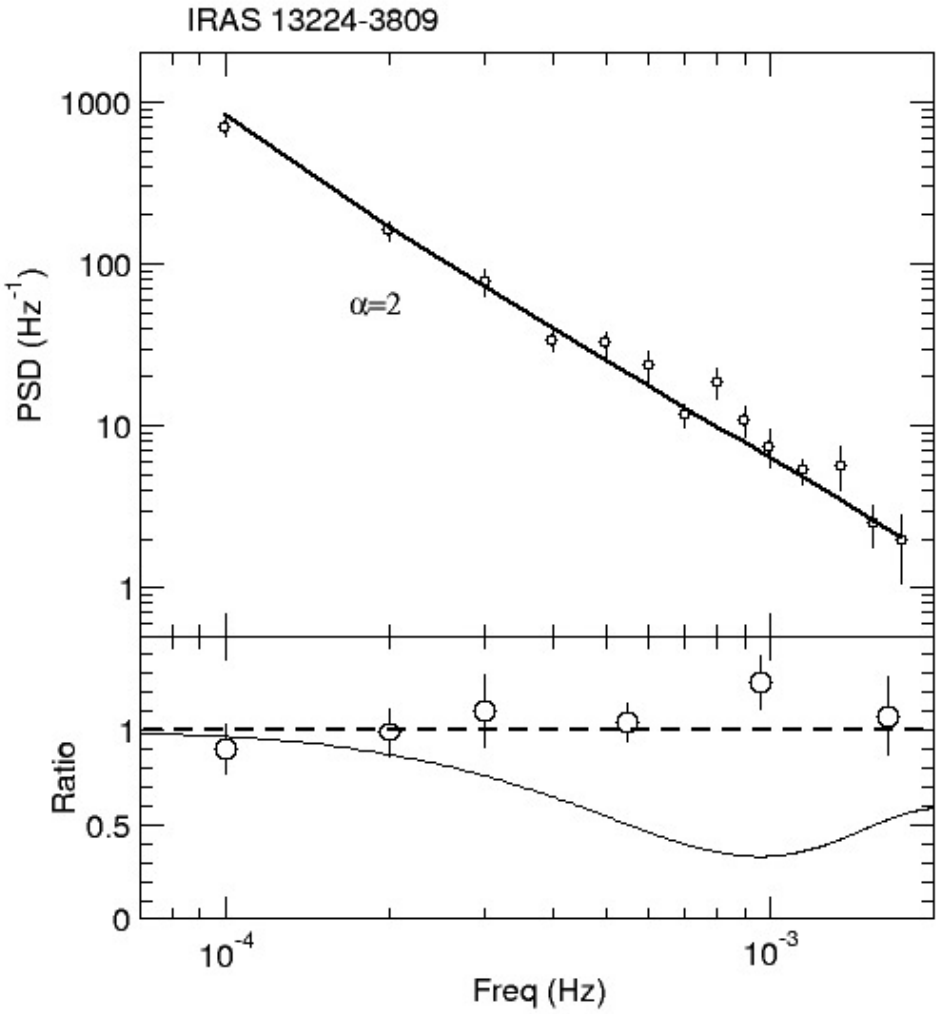
"bending power-law"
model fits the data well



"bending power-law" best-fit when α_{high} fixed at -2



But…


IRAS 13224-3809
1000
100
10
1
PSD (Hz^{-1})
α=2
1
0.5
0
Ratio
10^{-4}
10^{-3}
Freq (Hz)

Summary

✓X-ray reflection predicts PSD "echo"-features at high frequencies.

✓PSD modeling can be used to estimate the source height, spin and inclination angle.

✓There must be an agreement between the estimates from the spectral, time-lags and PSD modeling of a source.

Future plans:

Determine response functions for ionized discs and use them to predict the respective PSD echo features

Study carefully the existing PSDs to search for these "echo" features.