Reverberation Lags in AGN

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Outline

1. Lags in Galactic black holes?
2. Low frequency lags in AGN
3. High frequency lags in AGN
4. Conclusion
Energy spectra in GBH.

e.g. Remillard & McClintock 06, ARAA
Lags in Galactic black holes?
Low frequency lags in AGN
High frequency lags in AGN
Conclusion

Lags in GBH.

Miyamoto(89), Nowak et al. (99), Kotov et al. (01)
Lags in Galactic black holes?

Low frequency lags in AGN

High frequency lags in AGN

Conclusion

Lags in GBH

Energy Spectrum

Power Spectrum

Revnivtsev et al. (99,01), Kotov et al. (01)

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Reverberation Lags in AGN
Kotov et al. (01), McHardy et al. (04,07), Arevalo et al. (06),
1H0707-495 at low frequencies: Similar to BHB

Zoghbi et al. (11)
Low vs High frequency lags.

1H0707-495 at high frequencies: different

Reverberation Lags in AGN

Zoghi et al. (11)
There are **two** component of variability at low and high frequencies.

McHardy et al. (07), Zoghbi et al (10)
High frequency lags and the energy spectrum.

To understand it we need the spectrum.

Fabian et al. (09), Zoghbi et al. (10,11)
Modelling the high frequency lags.

The lag spectrum matches the spectrum very well.

Zoghbi et al. (11)
Energy-frequency plot.

Another way of looking at it.

Zoghbi et al. (11)
Energy-frequency plot.

1H0707 is not the only source.

1H0707-495

RE J1034+396

Zoghbi et al. (11b)
More on high frequency lags.

1H0707 is not the only source. When we have better data ...

Zoghbi et al. (in prep.)
Conclusion.

- From GBH: Low frequency lags are in the Comptonization component and **not** the distant reflection.
- The **same** low frequency component is present in AGN.
- In AGN, there is also **another** high frequency variability component with characteristic frequencies of few $R_g$, with different lag properties.
- The high-freq component is fully consistent with reverberation in the inner few $R_g$. 
Lags in Galactic black holes?
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Conclusion
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Conclusion
Statistics and systematics.
The shape is not altered, but stretched.
Lags in Galactic black holes?
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Conclusion

RE J1034+396

Obs. 1

Lag (s)
0
50
100
150
200

Obs. 2

−250
0
250
500
750

Energy (keV)
1
0.5
2
5

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