Insight into AGN from X-ray Observations of Mkn 766

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National Aeronautics and Space Administration Recap of new progress in general in the Fe K band. Absorption/emission inter-play Overview of narrow disklines

XMM data from Mkn. 766 Dísk Sígnatures Spectral Variability

Recap - what's new in the Fe K-band

High (> 10²³ cm⁻²) columns of high ξ gas suggested with detⁿ of ionized edges in Ginga data (Nandra & Pounds 1994)

Chandra/XMM confirm importance of such gas

To understand Fe K profiles this gas needs to be accounted for... Kallman et al 2004 N_H~ 3x 10²³ cm⁻², log ξ=2.25



 reduces implied broad red wing (Kinkhabwala 2003).....but zones isolated to date still leave some signature of reflection

New in Emission...

Narrow Fe lines, shifted from restenergy (Doppler/GR)

First obsⁿ in AGN - NGC 3516 (Turner et al 2002) simult. XMM /Chandra allowed detⁿ of weak features

Rapid (tens of ks) flux/energy variability - <u>must be</u> diagnostics of gas very close to BH

Suggested to be emission from disk hotspots integrated over partial orbits at tens-hundreds of r_q

NGC 3516 (Turner et al 2002)





Doppler-shifted Narrow Lines



> dozen reported, inferred origins few tens - hundreds of r_g strengthening link to disk



Large EWS a problem ?? Selection effect -currently only sensitive to large EW lines

Time to rethink the uniformity of the disk ?!

That EWs <u>can be</u> so large likely telling us we need to review disk emissivity

Possible uneven illumination - X-rays can be produced in intense localized flares on disk, leading to high EW from spots

Or lines may arise in

-areas of enhanced density in disk

-regions of warped geometry

More Specific Disk Diagnostics

Observed Energy /keV

Exciting disk interpretations suggested based on possible periodicity in these narrow/shifted components of Fe emission

Line energy varies with period ~ 165 ks as expected from orbital Doppler shifts



More Specific Disk Diagnostics



NGC 3516 April 2001



S/N

Periodicity in flux suggested Iwasawa et al (2004) for April data from NGC 3516

NGC 3516 Nov 2001



S/N

s/N S/N

NGC 5548



Energytime map of all the XMM data from Mkn 766



XMM observed Mkn 766 for 500 ks, June 2005

At low flux spectrum dominated by low ξ reflection high flux state dominated by PL <u>plus high-ξ reflection</u>

Warm absorber covers all components

cf previous discussions of variable PL, const reflⁿ to explain Seyfert spectral variability (Vaughan & Fabian '04)

-but this analysis aided by high-spectral-reslⁿ PCA (see Miller talk this afternoon) Flux selected spectra, XMM 2000-2005, Miller et al 2006





Fe K α flux continuum flux

He-like Fe emission correlated w/ continuum down to 10 ks (at least) -line lag 10 ks+/-10 ks

Prob by chance $\sim 2.3 \times 10^{-5}$



continuum

He-like Fe emission correlated w/ continuum

Mkn 766 - Miller et al 2006



line flux

He-like Fe emission correlated w/ continuum

He-like Fe emission originates in disk

Lag constraint -origin consistent with ~100 r_g found from 2001 data

Neutral Fe line not correlated w/ continuum but also variable

continuum

The most important result from Mkn 766 is that we are seeing significant Fe K emission from the disk and this is varying correlated with continuum - the diskline is not quite the same as we had previously thought ...



Complex & Variable Absorption



Fe XXVI abs revealed by H-like line originating in zone with log ξ~4, several x 10²³ cm⁻² covering the cool/const reflector

Absⁿ line disappears during observation, this var absⁿ is an additional level of complexity, 2nd-order effect in the gross spectral variability

Complex abs^n , several layers different ξ



Complex & Variable Absorption

Comment on yesterdays statement that by Occam's razor BL is simplest model -

Multi-layered absorbers with components in the $\log \xi \sim 3.5 - 5$ range with N_H $\gg 10^{23}$ cm⁻² are showing up in best S/N data and are clear indicators of absorbing layers not previously modelled - so not all `alternate' absorption models are <u>arbitrarily</u> complex



Observed Energy (keV)

Effect of Variable Absorption?



Can only be done by <u>occultation</u> - continuum & ionised reflector would then be inferred to be co-spatial because of the tightness of the line-continuum correlation

Occulting absorbers would need to be *partially-covering* the source and exist $\sim 100r_g$ Overall - too contrived ...



Summary

Mkn_ 766 illustrates how valuable long_ Seyfert' observations are:

He-líke Fe emíssíon líne correlated. w/ contínuum down to 10 ks (at least)

Spectral variability explained primarily by changes in relative levels of linked p/ionized-disk &cooler/less-variable reflector

Large column of ionized gas revealed through H-like Fe⁻ absⁿ and this varies on ~days - lesser contribution to spectral variability_

Can díagnose <u>inner dísk</u> most easily in Seyfert <u>hígh-states</u>