New results on the importance of absorption in shaping the X-ray properties of AGN

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NGC 3516

XMM, Turner et al. 2005

Long known to have multiple, variable layers of ionized gas

\[ N_{\text{HI}} \sim 6 \times 10^{21} \text{cm}^{-2} \quad \log \xi_1 \sim -0.5; \quad N_{\text{H}_2} \sim 10^{22} \text{cm}^{-2} \quad \log \xi_2 \sim 3 \]
High $N_H/\xi$ component isolated

Abs$^n$ lines Fe XXV, XXVI
$V \sim 1000$ km/s outflow

$N_H > 5 \times 10^{23}$ cm$^{-2}$  $\log \xi \sim 4.3$

Observed energies rules out local $(z=0)$ origin
Spectral & most of flux variability - changes in covering of log $\xi$ $\sim$ 2 layer, 40%-60% in $N_H \sim 10^{23}$ cm$^{-2}$

Covering variation also explains much of flux variability (cf NGC 4151 Puccetti et al 2007)
Occultation events in MCG-6-30-15 & NGC 3516

McKernan & Yaqoob 1998

Occultation by optically-thick cloud explains flux and spectral variability in target low state, including Fe emission line

Deep dips - eclipse type events?
Flat Bottomed Dips

MCG-6-30-15 McKernan & Yaqoob '98 - dip shape from inhomogeneities in emitter

Dip shape hard to explain in light-bending model?

Effective resolution ~ million greater than possible w/ current X-ray optics

NGC 3516 Turner et al '08 - dip shape - inhomogeneities in emitter or absorber

\[ d_{\text{cloud}} \sim 3 \times 10^{13} \text{ cm} \sim R_s \]
Compton-thick absorbers in type 1 AGN

New evidence from Suzaku that partial-covering by Compton-thick gas is important
Compton-thick Absorber in Type 1 QSO, 1H 0419-577 (Turner et al.

Very strong hard excess in HXD.
Cannot be fit by reflection
$N_H > 10^{24}$ cm$^{-2}$ covering >70% of emitter
$L_{bol} \sim 10^{47}$ erg/s
Located close to black hole (e.g. within BLR)
Signature of a thick disk wind?

Without PC absorption

With PC absorption

Observed energy (keV)

Observed Energy (keV)
Suzaku PIN Results

Flux above 10 keV generally stronger than expected from reflection models

MCG-6-30-15  R ~ 2-5  Ballantyne et al ‘03, Miniutti et al ‘07
NGC 4051     R ~ 7    Terashima et al 2008
Mrk 335      R ~ 2.8  Larsson et al 2008

1H 0419-577 & PDS 456 - fits require PC absorption
(see review Turner & Miller 2009, The Astronomy and Astrophysics Review: 17, 47; arXiv0902.0651)
Covering Fractions

PDS 456 - more marked hard excess (lower S/N)
also c.f. variable covering by large columns in
Mrk 766 0-60% (Miller et al ‘07, Turner et al ‘07)
NGC 3516 30-70% (Turner PDS et al ‘08)
MCG-6-30-15 50-100% (Miller et al ‘08)
also 1H0557-385 (Longinotti et al ‘09)
Partial Covering

Covering fractions < 1 -> absorber structure on same scale as continuum source. If clouds exist far from continuum - probability issue.

More likely scenario - X-ray absorber exists close-in as part of a clumpy (equatorial?) disk wind containing structures on many size scales

Preferred plane -> chance of seeing absorption depends on opening angle of wind

1H0419-577 f~10%, can be explained by an equatorial wind with opening angle ~12°
Summary

- Variable covering absorber can explain spectral shape & flux variability in NGC 3516.

- NGC 3516/MCG-6-30-15 light curves show dip events - favor absorption models - provide way to map AGN inner regions ahead of optics development.

- A number of AGN have strong flux above 10 keV further favoring absorption models.

- Physical explanation - disk winds - developing models look promising.

- Need Astro-H/IXO to determine the level of contribution from various regions.