Absorption at the Dust Sublimation Radius and the Dichotomy between X-ray and Optical Classification in the Seyfert Galaxy H0557-385

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X-ray Absorption Variability in AGN

A significant fraction of local Seyfert galaxies show evidence for continuum absorption in their X-ray spectra.

Measurements of variability timescales can be used to infer the distance to the absorbing medium.

Short timescale variability is often attributed to BLR clouds. (e.g. NGC 1365; Maiolino et al. 2010, Risaliti et al. 2007).

Longer variability timescales are associated with the circumnuclear torus (e.g. NGC 7582; Piconcelli et al. 2007).

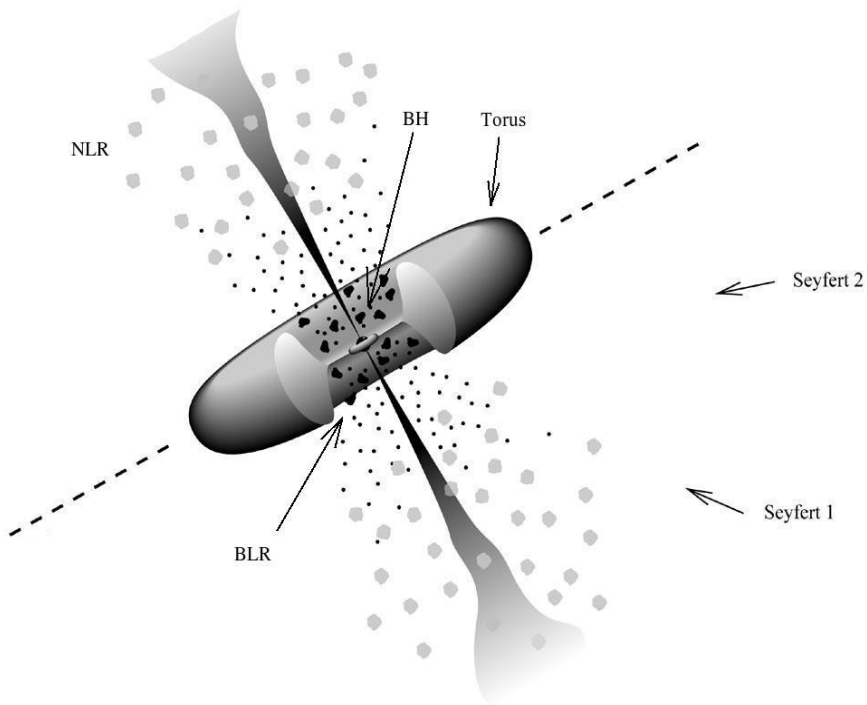
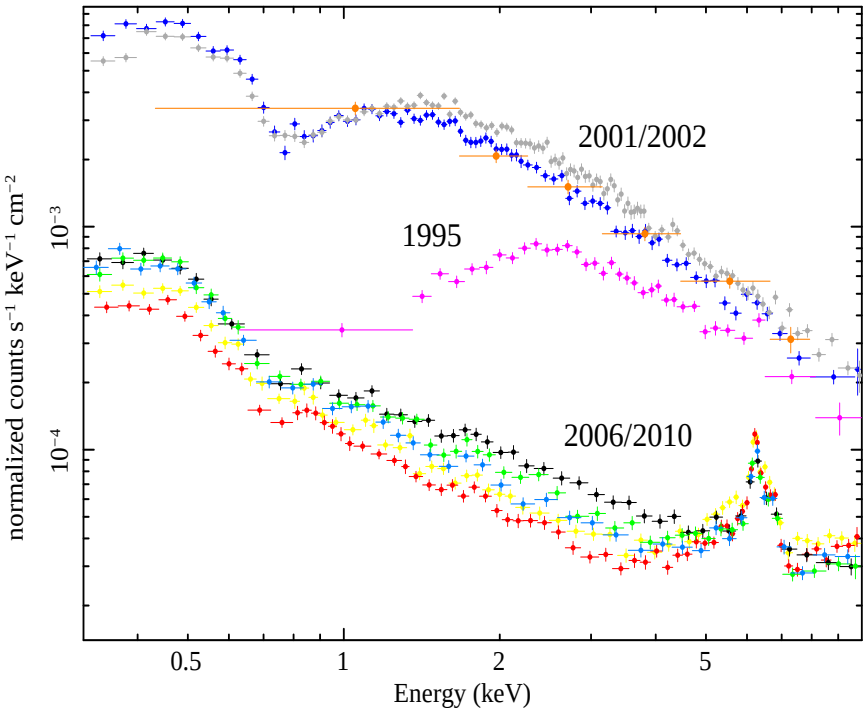


Figure: Urry & Padovani 1995 (adapted)

H0557-385: A "Changing-Look" Seyfert 1

Extensive *XMM-Newton* observation campaigns have revealed extreme X-ray variability on a time scale of several years.



Obs. #	Mission	Date year-month-day
1	ASCA	1995-03-23
2	BeppoSAX	2001-01-26
3	XMM	2002-04-04
4	XMM	2002-09-17
5	XMM	2006-08-11
6	XMM	2006-11-03
7	XMM	2010-10-15
8	XMM	2010-10-19
9	XMM	2010-10-31

Less dramatic variability observed among the low-state spectra on a time scale of weeks/months

H0557-385: Previous Work

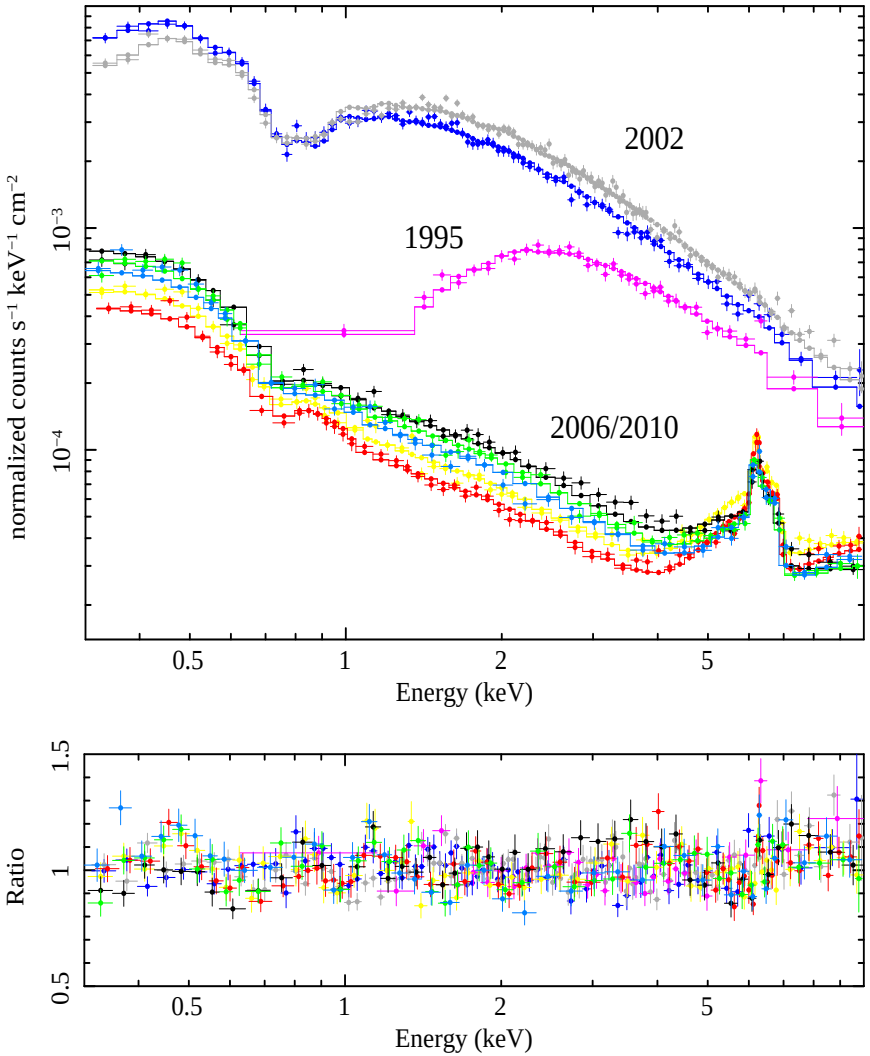
Ashton et al. (2006)

- Presented the 2002 *XMM-Newton* observations.
- Investigated the warm absorption present in the soft X-ray spectrum.
- Used a model consisting of a two-phase warm absorber, along with a neutral gas component.

Longinotti et al. (2009)

- Presented the low-state data which showed a drop in flux by a factor of ~ 10.
- Low-state model included a partial covering absorption component.
- Showed that transitions between the two states can be attributed to a neutral absorber attenuating the primary emission.

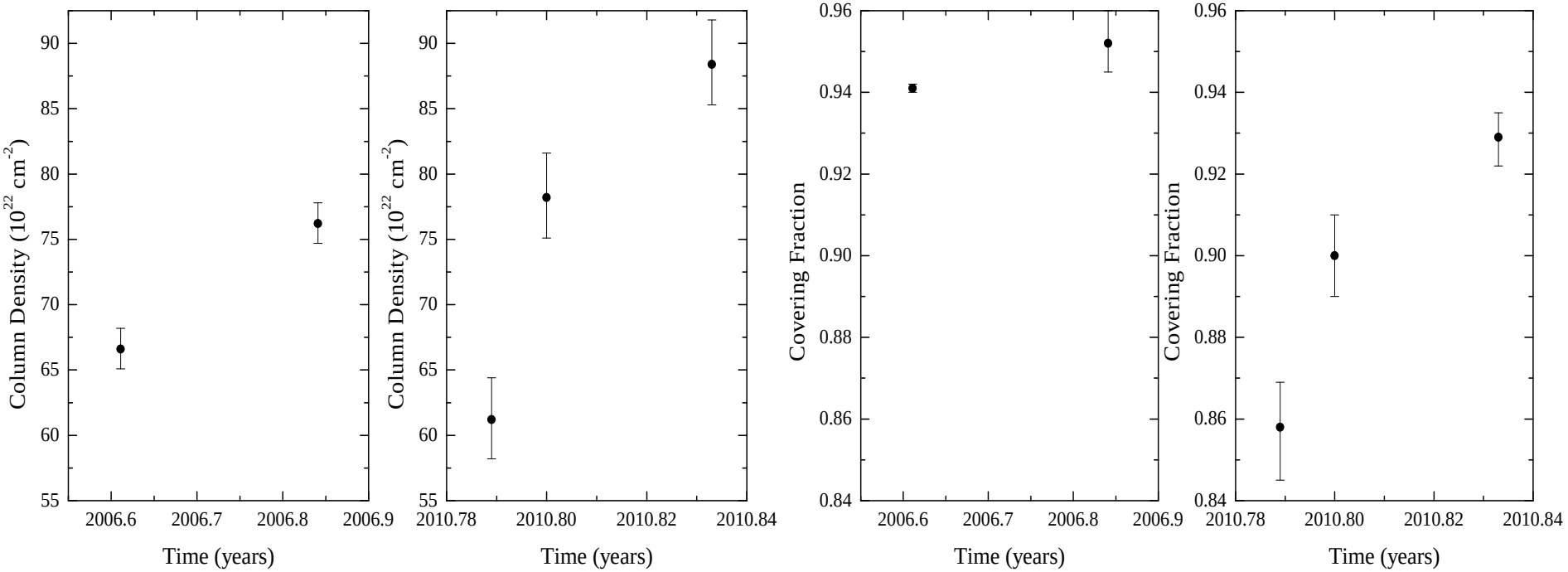
Designing the Spectral Model



- Intrinsic AGN power law
- Warm absorption (ZXIPCF)
- Compton reflection (PEXMON)
- Collisionally ionised emission (APEC)
- Transition between states due to variable neutral absorber (ZPCFABS)

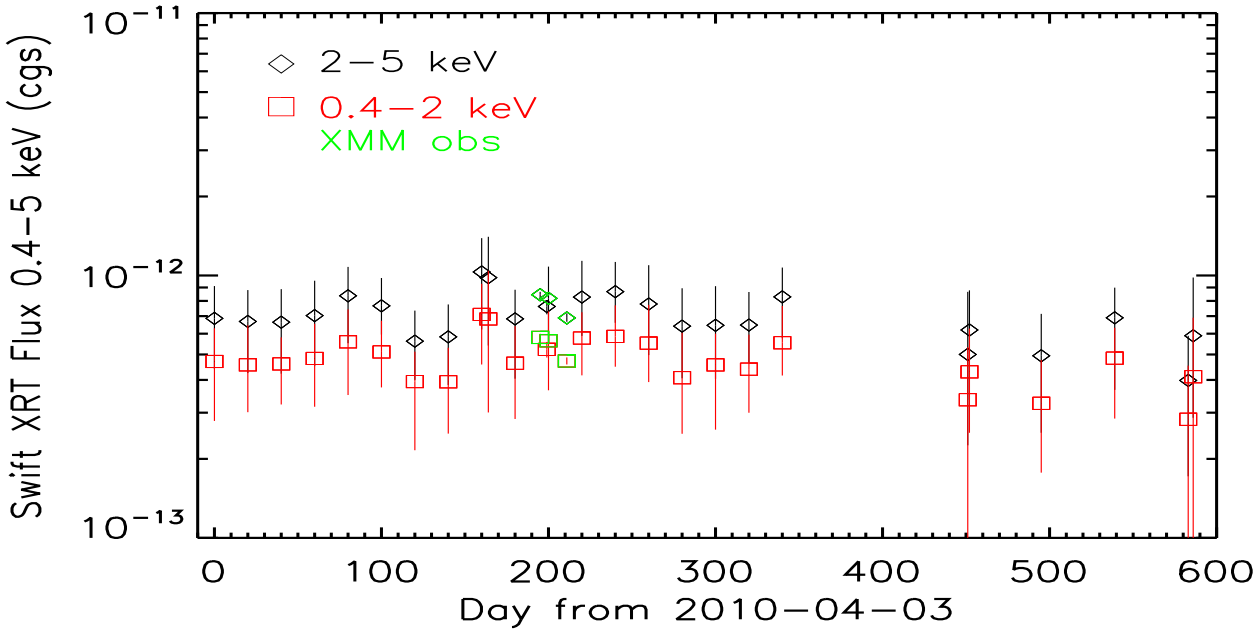
Results From the Spectral Model

Transition between states require a Compton-thin ($N_H \sim 10^{23}\,cm^{-2}$) neutral absorber covering more than 80% of the X-ray source.



Swift XRT Data

Search for short (days/weeks) timescale variability: *Swift* monitoring, 2010 March - 2011 November.



H0557-385 is not observed to revert back to its high-state on short timescales

Origin of the X-ray Variability

Multiple observations provide upper limit on variability time scale ΔT.

Cloud velocity estimates;

- Velocity of BLR clouds estimated from FWHM of emission lines.
- Distance to dust sublimation radius: $R_d \propto L^{0.5}$
- Calculate velocity of material at R_d assuming Keplerian motion.

Origin of the X-ray Variability

Cloud diameter, D_c, found from

$$D_c \geq V_c \Delta T + D_s$$

(Miniutti et al. 2014) where $D_s \sim 10 R_g$ is the X-ray source size.

Cloud number density (cm^{-3}) found from cloud column density, N_H,

$$N_e = \frac{N_H}{D_c}$$

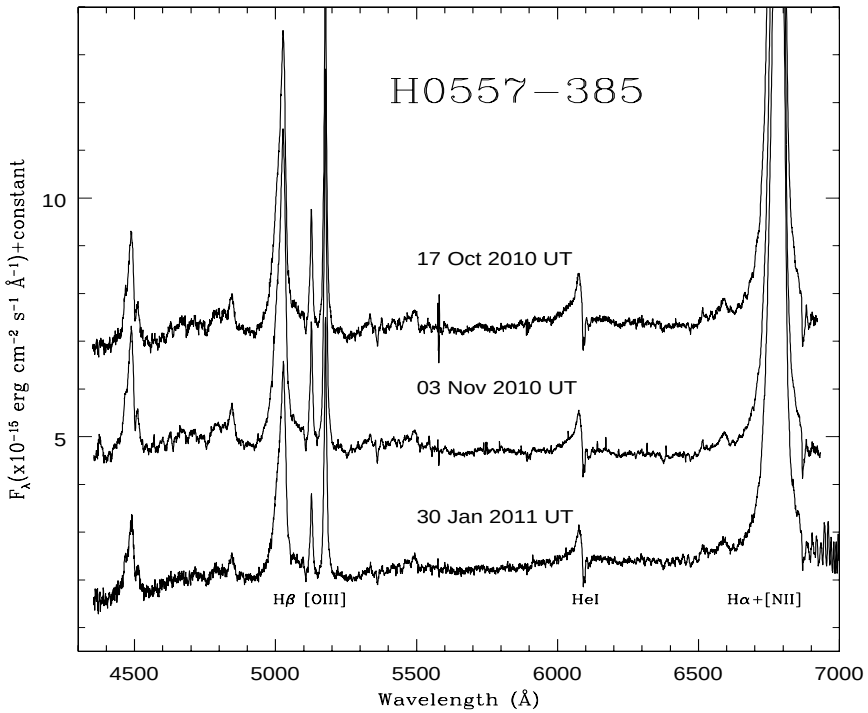
Properties of the Absorbing Material

Obscuring clouds can be associated with material at the dust sublimation radius, a distance $R_d \simeq 2\times10^{18}$ cm from the X-ray source.

Cloud Properties	
N_H (cm^{-2})	7.4×10^{23}
V_c ($km\,s^{-1}$)	650
D_c (cm)	3×10^{15}
N_e (cm^{-3})	2×10^{8}

Optical Spectroscopy Measurements

SOAR/Goodman optical spectroscopic observations, November 2010 - January 2011.



- Optical observations concurrent with 2010 *XMM-Newton* observations.
- Broad emission lines detected during an X-ray absorption event.

Conclusions

Dramatic X-ray variability attributed to absorption by a neutral Compton-thin absorber.

Variability timescales suggest that absorber forms part of the inner torus.

Observation of broad optical emission lines suggests that the absorber must be dust-free.

H0557-385 does not fit in to the traditional Unification Model for AGN.

Unusual, but not unique; X-ray and Optical Classification may give contrasting results for $\sim$30% of AGN. (Merloni et al. 2014).