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


Presenting Author

Damien Coffey

School of Physics, Trinity College Dublin
ESAC, ESA

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

<table>
<thead>
<tr>
<th>Obs. #</th>
<th>Mission</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ASCA</td>
<td>1995-03-23</td>
</tr>
<tr>
<td>2</td>
<td>BeppoSAX</td>
<td>2001-01-26</td>
</tr>
<tr>
<td>3</td>
<td>XMM</td>
<td>2002-04-04</td>
</tr>
<tr>
<td>4</td>
<td>XMM</td>
<td>2002-09-17</td>
</tr>
<tr>
<td>5</td>
<td>XMM</td>
<td>2006-08-11</td>
</tr>
<tr>
<td>6</td>
<td>XMM</td>
<td>2006-11-03</td>
</tr>
<tr>
<td>7</td>
<td>XMM</td>
<td>2010-10-15</td>
</tr>
<tr>
<td>8</td>
<td>XMM</td>
<td>2010-10-19</td>
</tr>
<tr>
<td>9</td>
<td>XMM</td>
<td>2010-10-31</td>
</tr>
</tbody>
</table>

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 \( \sim 10 \).
- 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 \((N_H \sim 10^{23} \text{ cm}^{-2})\) neutral absorber covering more than 80% of the X-ray source.
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 $\Delta T$.

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.
Cloud diameter, $D_c$, found from

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

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

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

$$N_e = \frac{N_H}{D_c}$$
Obscuring clouds can be associated with material at the dust sublimation radius, a distance $R_d \approx 2 \times 10^{18}$ cm from the X-ray source.

<table>
<thead>
<tr>
<th>Cloud Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_H$ (cm$^{-2}$)</td>
<td>$7.4 \times 10^{23}$</td>
</tr>
<tr>
<td>$V_c$ (km s$^{-1}$)</td>
<td>650</td>
</tr>
<tr>
<td>$D_c$ (cm)</td>
<td>$3 \times 10^{15}$</td>
</tr>
<tr>
<td>$N_e$ (cm$^{-3}$)</td>
<td>$2 \times 10^8$</td>
</tr>
</tbody>
</table>
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 ~30% of AGN. (Merloni et al. 2014).