Anatomy of the AGN in NGC 5548: Tracking evolution of the obscuration with Swift

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&

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Swift monitoring:

<table>
<thead>
<tr>
<th>Year</th>
<th>Frequency</th>
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</thead>
<tbody>
<tr>
<td>2012</td>
<td>~ every week</td>
</tr>
<tr>
<td>2013</td>
<td>~ every 2 days</td>
</tr>
<tr>
<td>2014</td>
<td>~ every day</td>
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What do we see over a few years with Swift monitoring?

1. Variability of the underlying X-ray/UV emission

2. Evolution of the foreground obscurer

Figure credit: Renaud Person
Examples of X-ray spectral variability in NGC 5548

Both continuum and obscuration variability
2013-2014 Swift lightcurves of NGC 5548

Swift XRT (0.3–1.5 keV)

Swift XRT (1.5–10 keV)

Hardness ratio

Swift UVOT (UVW2)

$10^{-14} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ Å}^{-1}$

Time

1 Jul 2013 – 1 Jan 2014

500 days
1) First, produced a model using data before the source became obscured (XMM 2000 & 2001).

Optical-UV-X-ray modelling ingredients

**soft X-ray excess**

Counts/m²/s/Å

Residuals

NGC 5548
EPIC-pn (2000)
Optical-UV-X-ray modelling ingredients

2) Adopted the obscurer + warm absorber model derived from XMM + NuSTAR + INTEGRAL 2013 data.
Optical-UV-X-ray modelling ingredients

3) Established the optical-UV continuum using HST COS, Swift UVOT and XMM OM data

![HST COS](image)

![UVOT & OM grisms](image)

1100-6900 Å
Relation between the ‘soft X-ray excess’ and UV

Soft excess (0.3−2 keV) luminosity ($10^{43}$ erg s$^{-1}$) vs. UV flux at 2030 Å (Jy)

Mehdipour et al. (in prep)

Swift 2007

XMM 2000, 2001
Relation between the ‘soft X-ray excess’ and UV

Mehdipour et al. (in prep)

XMM 2000, 2001

Swift 2007

NGC 5548 Swift 2013, 2014
Optical-UV-X-ray continuum model

Warm Comptonisation produces the soft X-ray excess

See e.g. Magdziarz et al. (1998), Mehdipour et al. (2011), Petrucci et al. (2013), Done et al. (2012, 2013)

\[ T_c \sim 0.2 \text{ keV} \]
\[ \tau \sim 20 \]

\[ T \sim 3 \text{ eV} \]

\[ \Gamma \sim 1.75 \]
Long-term variability of the obscurer & soft X-ray excess

Hedir et al. (in prep)
Variability of the X-ray obscurer

NGC 5548
Swift data

Warmer-phase
$N_H \approx 10^{22} \text{ cm}^{-2}$

Colder-phase
$N_H \approx 10^{23} \text{ cm}^{-2}$

$\sim 5000 \text{ km s}^{-1}$

Mehdipour et al. (in prep)
Correlation between UV & X-ray lightcurves at different energies

Dip caused by the obscurer variability

Mehdipour et al. (in prep)
The X-ray obscurer (stream of outflowing gas near the disk) has been continuously present for a few years.

The obscuring material is constantly being replenished from the accretion disk.

Changes in obscuration (covering fraction) produces the observed X-ray hardness ratio variability.

The colder phase (dense clumps) of the obscurer varies on a shorter timescale (days) than its warmer medium (months).

There is a direct link between UV and soft X-ray excess. Soft excess origin: optically thick, warm Comptonisation.