X-ray Obscured Type 1 AGN in BASS

Nikita Kamraj
California Institute of Technology
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OBSCURED TYPE 1 AGN IN BASS

- Optically classified as Type 1
- X-ray column density $> 10^{22}$ cm$^{-2}$

Koss et al. 2017
OBSCURED TYPE 1 AGN IN BASS

SWIFTJ0227.0+2346

SWIFTJ0814.3+0423

SWIFTJ0830.4-6723
OBSCURED TYPE 1 AGN IN BASS

Figure 1. 

\[ N_H \] distribution for the Sy 1s, 1.2s, 1.5s, 1.9s in our Type 1 AGN sample and Sy 2s in the full BASS sample. Red dashed lines indicate the median \( N_H \) for each subsample excluding \( N_H > 10^{24} \) cm\(^2\) to avoid incompleteness. \( N_H = 10^{20} \) cm\(^2\) is the lowest column density that is able to be measured in the X-ray due to Galactic absorption.

Sy 1.9s, there is either more or different gas and dust hiding the central X-ray source than there is in front of the BLR. This is also shown by comparing X-ray derived \( N_H \) values with the broad H\( \alpha \) derived \( A_V \) values illustrated in Fig. 3. For most of the Sy 1–1.5s, both \( N_H \) and \( A_V \) are low whereas the Sy 1.9s form the majority of the high \( N_H \) and high \( A_V \) Type 1 AGN. Below \( A_V = 3 \) mag, most of the AGN either scatter around the gray shaded line, which represents the spread of typical gas-to-dust ratios \( (DGR) \) found in our Galaxy \( (N_H / A_V = 1.79 \pm 0.69 \times 10^{21} \) cm\(^2\)), or lie along \( N_H = 10^{20} \) cm\(^2\) or \( A_V = 0 \) mag. Above \( A_V = 3 \) mag, all but one AGN is a Sy 1.9 and all either lie on the Galactic DGR line or above it, sometimes with several orders of magnitude more column density than expected for a Galactic DGR.

Fig. 3 confirms the findings of Schnorr-Müller et al. (2016) and Burtscher et al. (2016). Both of these studies, through independent methods, found that intermediate Seyferts typically display moderate optical obscuration \( (A_V = 4 \pm 8) \) mag. The similarity between the two previous studies and ours validates our relatively simple method for measuring the optical obscuration towards the BLR. With our much larger sample, though, we find a much larger range in \( N_H \) values for Sy 1.9s. Whereas Burtscher et al. (2016) determined that using \( \log N_H = 22.3 \) cm\(^2\) as a threshold for X-ray absorbed AGN consistently classified Sy 1.9s as unobscured objects, we find that Sy 1.9s instead span \( \log N_H \) values all the way up to 25. Indeed, 12/39 (32%) of Sy 1.9 have \( N_H \) measurements above this threshold. Sy 1.9s represent 60% of the Type 1 AGN that can be considered X-ray absorbed using a threshold of \( \log N_H > 22.3 \) cm\(^2\), which leads to a total X-ray absorbed, Type 1 AGN frequency of 10%. Lowering the threshold for X-ray absorbed AGN to \( \log N_H = 21.5 \) cm\(^2\) increases the frequency to 20% so we can confidently say the X-ray absorbed fraction within Type 1 AGN is between 10 and 20%. These fractions are more in agreement with the results of Perola et al. (2004) and nearly a factor three smaller than the rates found by Tajer et al. (2007) and Merloni et al. (2014).

What is further clear from this study is that the hydrogen column densities measured from the X-ray spectra are generally much larger than those measured from the BLR extinction assuming a Galactic GDR.
OBSCURED TYPE 1 AGN IN BASS

- ~14% of Sy 1-1.9 from BASS sample are X-ray absorbed
- BLR provides extra obscuration towards corona

Shimizu et al. 2017
PHYSICAL SCENARIOS

- Neutral, dust free torus
- Line of sight grazing edge of torus
- Cloud passing line of sight in clumpy torus
- Ionized gas outflows

M. Elitzur 2006
NuSTAR OBSERVATIONS OF 2MASX J19301380+3410495

2016 obs, 20 ks

2017 obs, 50 ks
Optical spectra consistently show broad Hα and Hβ lines → Type 1 AGN
X-RAY SPECTRAL MODELING

- Archival Swift/BAT, XRT, XMM spectra show $N_H > 10^{23}$ cm$^{-2}$
- XSPEC models (this work):
  1. $\text{zphabs} \times \text{cabs} \times \text{cutoffpl} + \text{pexrav} + \text{zgauss}$ + (const. $\times$ cutoffpl)
  2. $\text{cabs} \times \text{Tbfeo} \times \text{cutoffpl} + \text{pexmon}$ + (const. $\times$ cutoffpl)
  3. Borus

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*Hogg et al. 2012*
X-RAY SPECTRAL MODELING

Data:

- NuSTAR – 2016 (up to 30 keV) + 2017 (3-79 keV)
- Archival XMM – 2009 (PN+MOS1+MOS2)
- Swift/BAT 70-month averaged spectra
X-RAY SPECTRAL MODELING

Borus model
### X-RAY SPECTRAL MODELING

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$/dof</th>
<th>NuSTAR 2017 $N_H$ (cm$^{-2}$)</th>
<th>$\Gamma$</th>
<th>$E_{\text{cut}}$ (keV)</th>
<th>$R$</th>
<th>Fe abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>pexrav</td>
<td>826/798</td>
<td>(3.8±0.3) x 10$^{23}$</td>
<td>1.35$^{+0.18}_{-0.15}$</td>
<td>49.9$^{+19.0}_{-11.2}$</td>
<td>-[0.90$^{+0.23}_{-0.32}$]</td>
<td>1 (fixed)</td>
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<tr>
<td>pexmon</td>
<td>806/798</td>
<td>5.5$^{+0.7}_{-0.5}$ x 10$^{23}$</td>
<td>1.33$^{+0.21}_{-0.14}$</td>
<td>49.9$^{+38.3}_{-13.2}$</td>
<td>-[0.70$^{+0.10}_{-0.22}$]</td>
<td>1.09</td>
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<tr>
<td>borus</td>
<td>808/795</td>
<td>4.9$^{+0.5}_{-0.7}$ x 10$^{23}$</td>
<td>1.73$^{+0.05}_{-0.27}$</td>
<td>71.9$^{+24.2}_{-41.0}$</td>
<td>-</td>
<td>0.45$^{+0.06}_{-0.05}$</td>
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</table>
FUTURE PLANS

• NuSTAR Cycle 5 proposal to study subsample of obscured type 1 AGN

• Currently available X-ray data: NuSTAR 20 ks legacy survey observations of some sources

• Ideas/thoughts/comments?
AGN UNIFICATION

Seyfert 2 (Sy2)

Seyfert 1 (Sy1)

Urry & Padovani 1995