Estimating the Intrinsic Luminosities of Heavily Obscured AGN

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Introduction

Active Galactic Nuclei (AGN) are accreting supermassive black holes (SMBH) at the centers of galaxies. The X-ray spectrum an AGN produces interacts with the surrounding accretion disk and dense torus of material (Figure 1). These interactions imprint their signatures on the X-ray spectrum, providing insight into the physical properties of the AGN. Here, we develop a physically-motivated standard model to predict the intrinsic (pre-interaction) luminosity of the AGN.

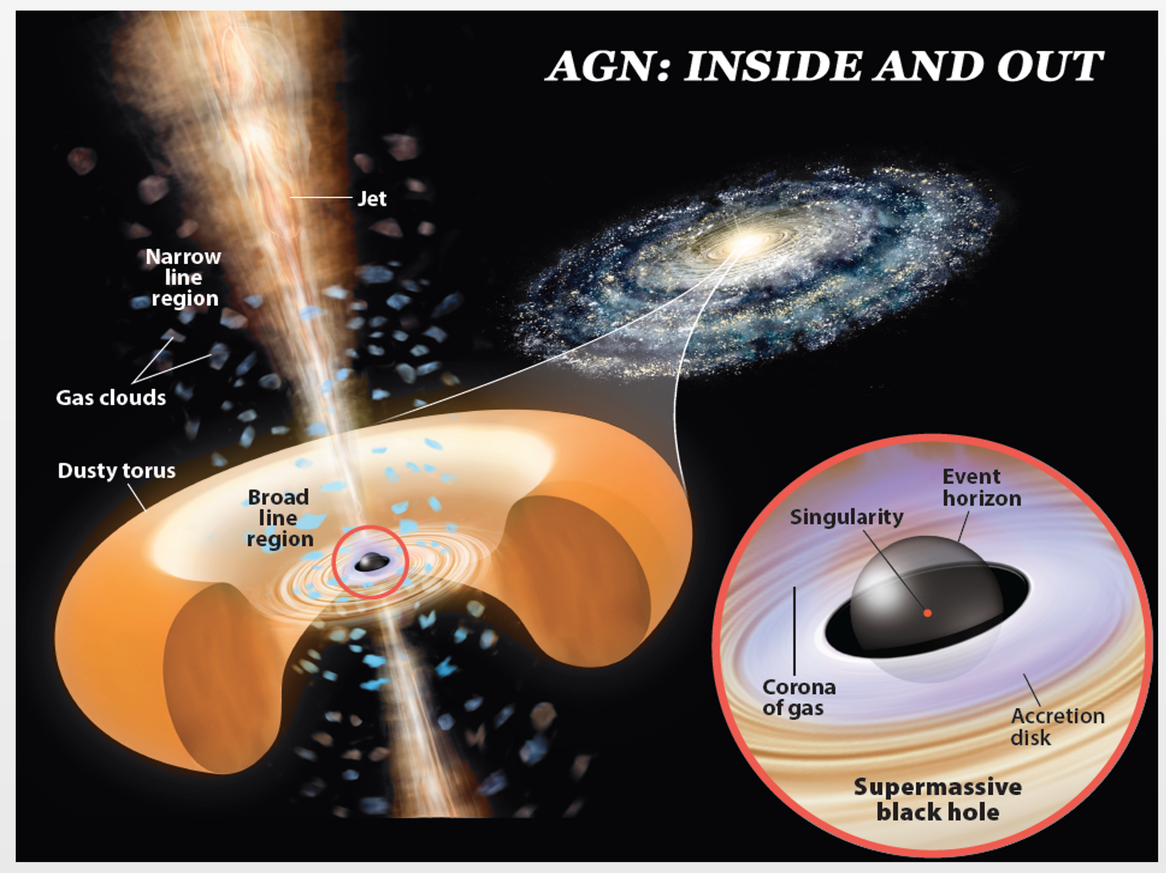

Figure 1: The structure of an AGN.
(Roen Kelly, Astronomy.com)

Sample

- **9** local AGN with high-quality spectra, spanning a broad absorption range: MCG -05.23.16, Mrk 3, NGC 262, NGC 2110, NGC 4507, NGC 5728, NGC 6814, NGC 7172, NGC 7582
- **3-79 keV** spectra from NASA's Nuclear Spectroscopic Telescope Array (NuSTAR)
- Modeled using NASA's HEASoft spectral analysis software

The Model

```
phabs*(atable{borus02_v170323c.fits}+zphabs*cabs*cutoffpl+constant*cutoffpl
 (1)                (2)                     (3)                 (4)
```

1. Galactic line-of-sight absorption
2. Reprocessing by dense material surrounding SMBH → includes reflection and scattering, fluorescent lines, and Compton shoulder
3. Absorbed intrinsic continuum → includes photoelectric absorption and Compton scattering effects
4. Scattered component → photons scattered into line-of-sight by obscuring material

Parameter	Label	Best-Fit	Standard Model
Γ	a	1.56985	1.70 (f)
E_{cut}	b	67.0057	200.00 (f)
$log(nH_{tor})$	c	24.5319	24.00 (f)
θ_{tor}	d	62.2509	55.00 (f)
θ_{inc}	e	66.1462	65.00 (f)
nH	f	33.4355	32.6645
f	g	0.0418	0.02 (f)

Table 1: Best-fit and standard model parameters for NGC 7582. (f) denotes a fixed value.
a) Photon index
b) Power law cutoff energy (keV)
c) Average torus column density
d) Torus opening angle
e) Torus inclination angle
f) Obscuring column density (10^{22} atoms cm^{-2})
g) Scattering factor

Methods

- Best-fit parameters (Table 1) determined by fitting each object using the `Xspec` model syntax above. Parameters for these fits were unconstrained, with parameters of components (3) and (4) tied to those of component (2).
- Standard model parameter values (Table 1) chosen based on median best-fit parameter values and 1σ error bounds.
- Standard model predicted column densities (Figure 3) determined using the same parameter ties as the best-fit model, with all parameters except column density frozen at standard values.
- Luminosity estimates (Figure 4) calculated using the predicted 2-10 keV flux from a power law model, with parameters set to those of the best-fit and standard models.

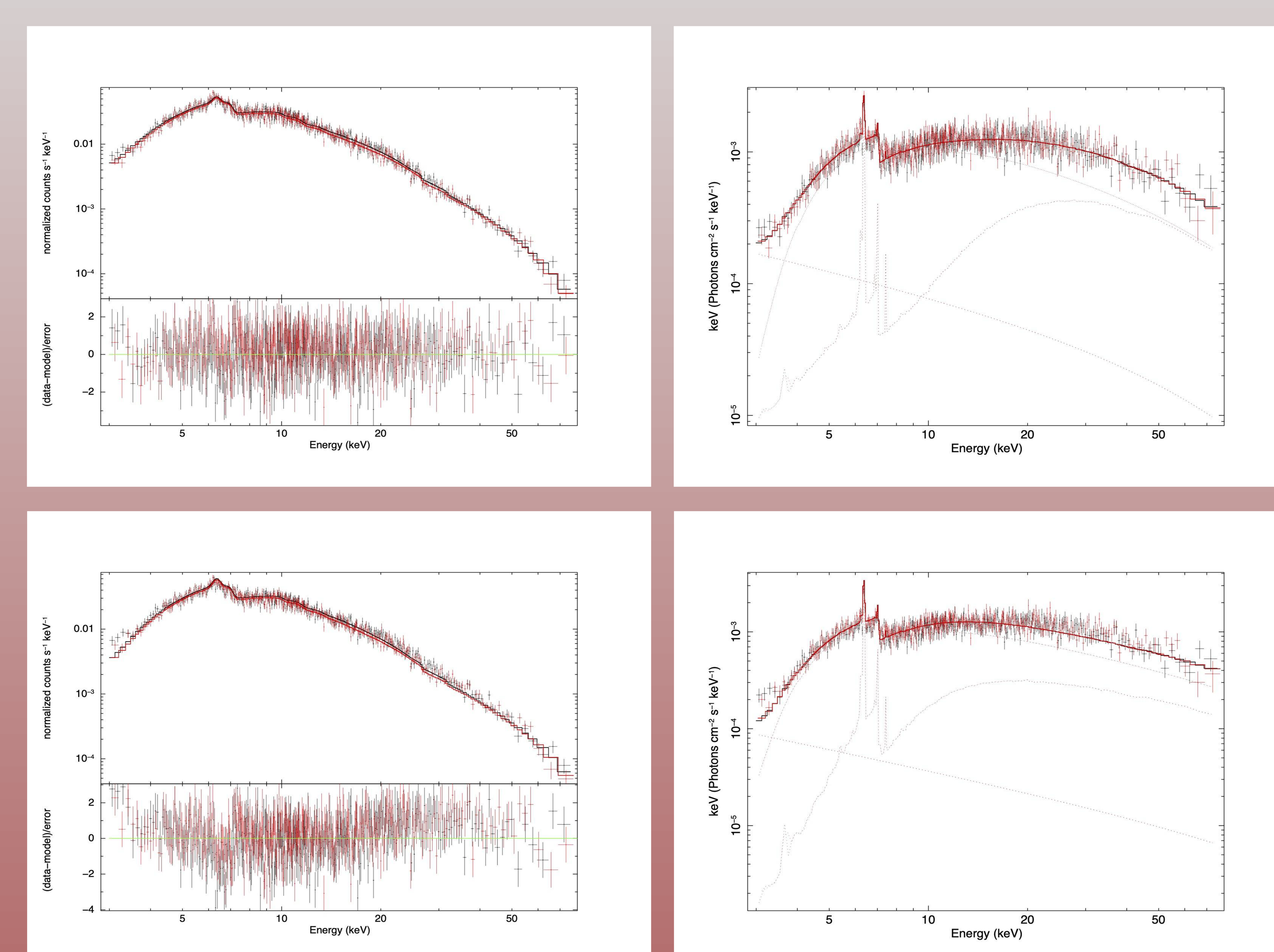

Figure 2: Best-fit (above) and standard (below) models for NGC 7582. Left: total model and residuals. Right: unfolded model components.

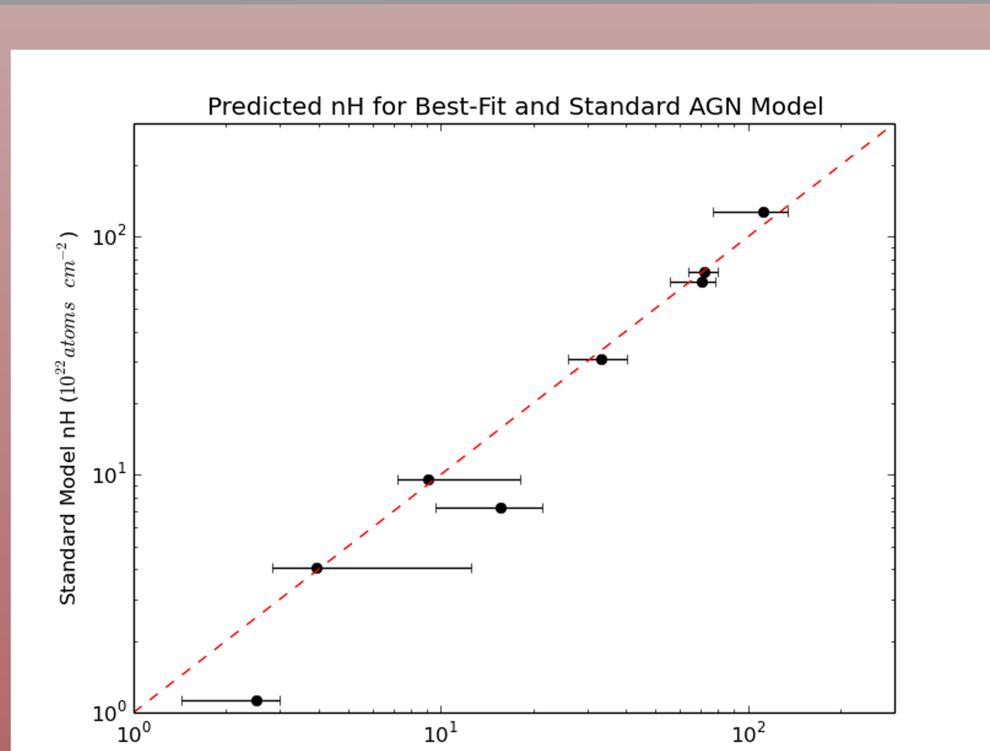

Figure 3: Best-fit and standard model obscuring column densities for sample objects. Dashed line indicates $nH_{best\text{-}fit} = nH_{standard}$

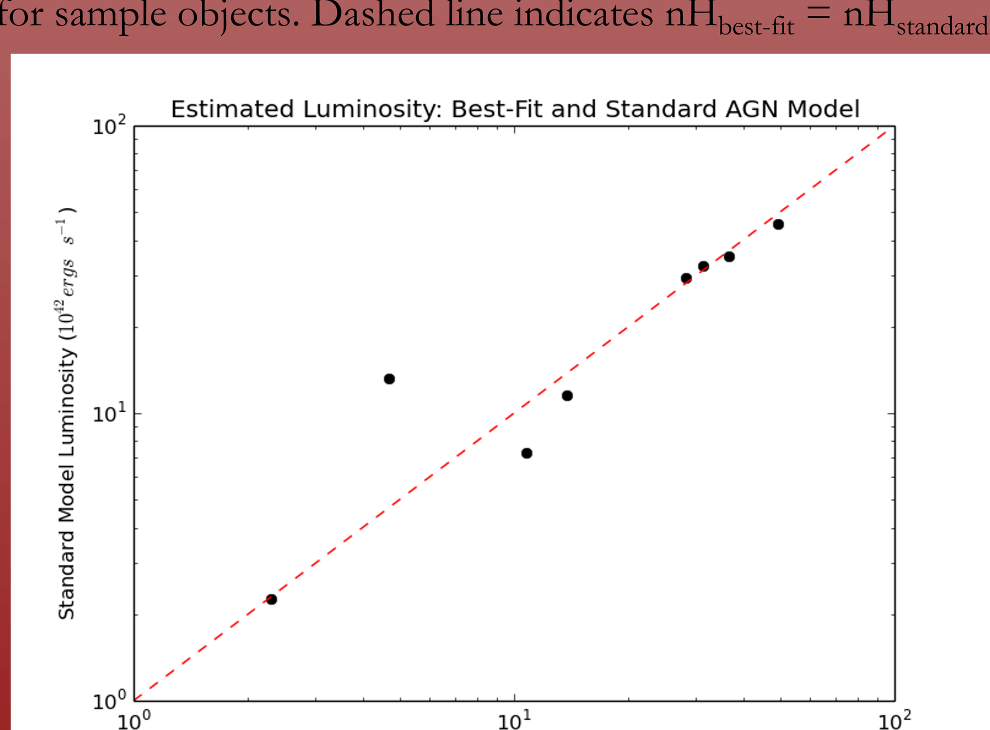

Figure 4: Best-fit and standard model luminosities for sample objects. Dashed line indicates $L_{best\text{-}fit} = L_{standard}$

Results

- Our standard model estimates obscuring column densities (Figure 3) and intrinsic luminosities (Figure 4) comparable to those predicted by the best-fit model.

Note: NGC 6814 has been omitted in Figures 3 and 4 due to lack of NuSTAR sensitivity at low obscuring column densities.

Future Work

- Further examine how standard model parameters affect obscuring column density and luminosity estimates
- Apply standard model to a large sample of similar AGN with low-quality data, to acquire high-confidence luminosity estimates

References

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