Suzaku Observations of Compton-thick Active Galactic Nuclei Selected by Swift/BAT Survey

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Abstract

We present a uniform broadband X-ray (0.5-100 keV) spectral analysis of 12 Swift/Burst Alert Telescope (BAT) selected Compton-thick (log N_H/cm^{-2} > 24) Active Galactic Nuclei (CTAGNs) observed with Suzaku (Tanimoto et al. submitted to ApJS). We fit the Suzaku and Swift/BAT spectra with utilizing the Monte Carlo based model from an AGN torus by Ikeda et al. (2009). The main results are as follows. (1) Unabsorbed reflection components are commonly observed, suggesting that the tori are clumpy. (2) Most of CTAGNs (10/12) show small scattering fractions (<0.5%) implying the buried AGN nature. (3) We find no evidence that CTAGNs are distinct populations from Compton-thin AGNs. Comparison with the results of Compton-thin AGNs (Kawamuro et al. 2016) suggests that the properties of these CTAGN can be understood as a smooth extension from Compton-thin AGNs with heavier obscuration.

1. Compton-thick AGN

Compton-thick (log N_H/cm^{-2} > 24) Active Galactic Nuclei (CTAGNs) are key objects to understand the origin of the Cosmic X-ray Background (CXB)[14,15] and co-evolution between SuperMassive Black Holes (SMBHs) and their host galaxies[09].

According to a SMBH evolutionary scenario[03], major mergers trigger violent star formation and rapid SMBHs growth obscured by gas and dust. This leads to the idea that some CTAGNs may be distinct populations from less obscured AGNs[12]. However, it remains an open question whether CTAGNs are intrinsically same objects or not as the rest of AGNs in terms of their nucleus structure, host galaxy properties, and cosmological evolution.

2. X-ray Observation and Sample

Hard X-ray (>10 keV) catalogs provide one of the least-biased AGN samples thanks to the strong penetrating power against obscuration.

Sample is 12 CTAGNs from Ricci et al. (2015) (subsample of Swift/BAT 70-month catalog[02]) observed by Suzaku[10].

Galaxy name	Redshift	Classification	log(M_{BH}/M_{Sun})
CGCG 420-015	0.0294	E	...
ESO 137-G034	0.0090	SBa	8.02
ESO 323-G032	0.0160	SBa	...
ESO 565-G019	0.0163	E	...
Mrk 3	0.0135	S0	7.96
NGC 1194	0.0136	S0	7.85
NGC 3393	0.0125	SBa	7.20
NGC 4945	0.0019	SBc	6.14
NGC 5728	0.0093	SBa	8.05
NGC 6552	0.0265	SBa	...
NGC 7130	0.0162	Sa	7.48
NGC 7582	0.0052	SBa	7.56

Table 1. Information on targets. M_{BH} is quoted from Izumi et al. (2016) and Botch et al. (2016).

3. Ikeda Torus Model

The Ikeda torus model[07] assumes a nearly spherical geometry and uniform density tori. This model has 3 free parameters: hydrogen column density along the equatorial plane, inclination angle of the observer and half-opening angle of the torus (Figure 1)

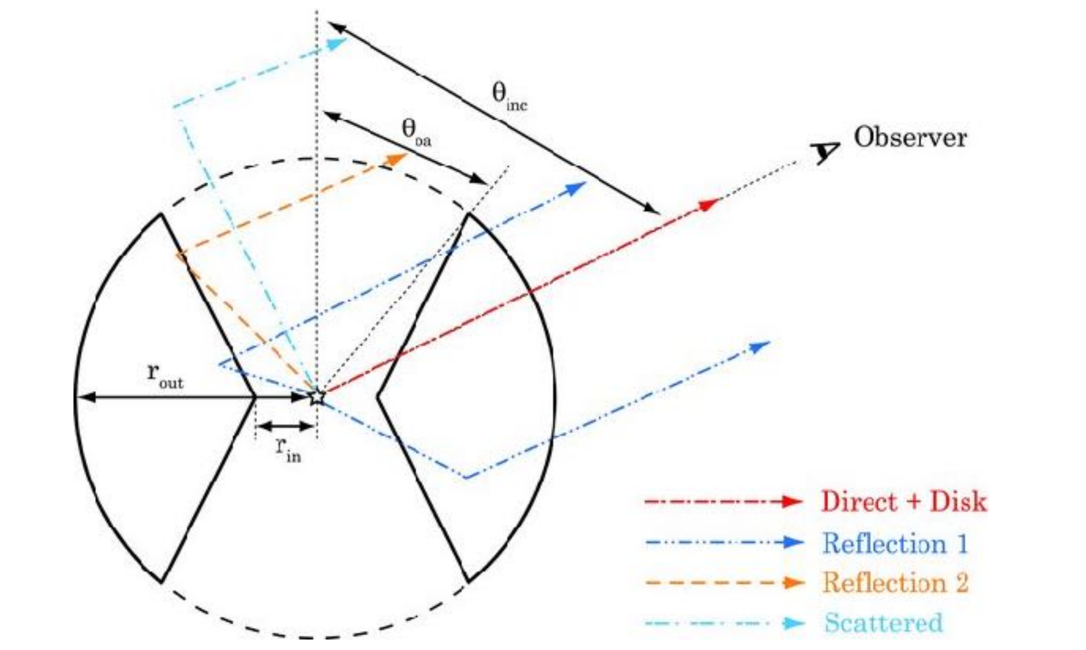

Figure 1. Cross section view of the torus geometry assumed in Ikeda et al.(2009).

4. Broadband X-ray Spectrum

Figure 2. plots the unfolded spectrum in units of EF_E for CGCG 420-015.

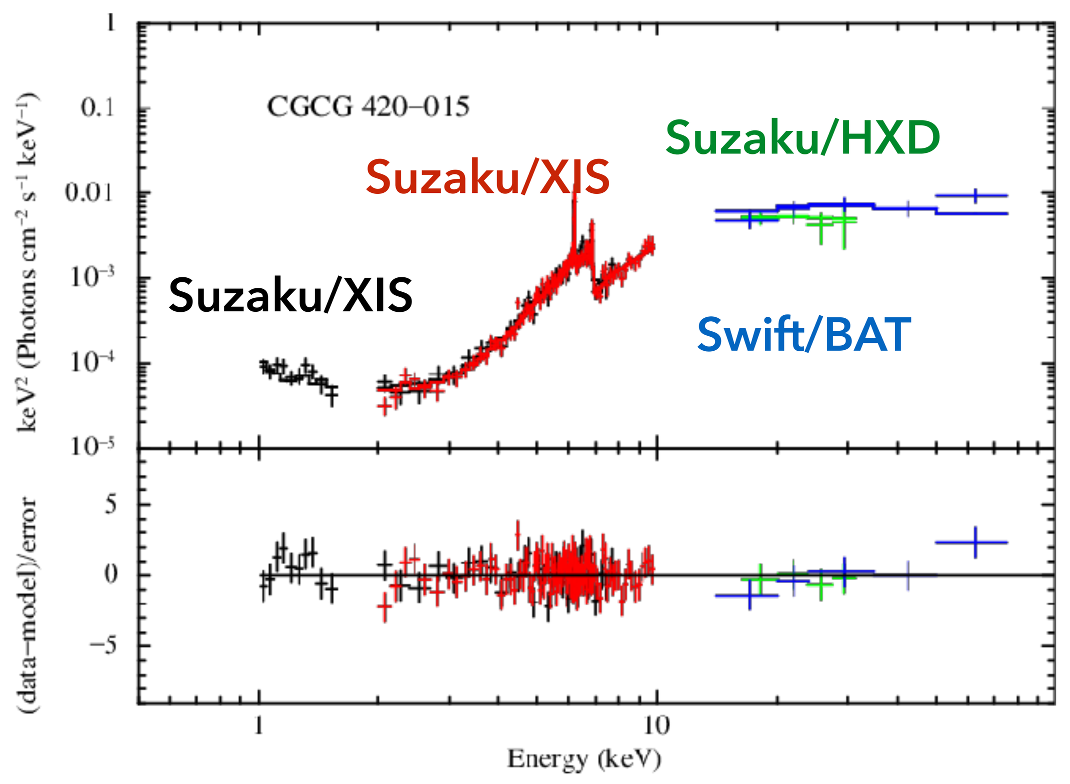

Figure 2. The unfolded spectrum (Suzaku/BIXIS (Black), Suzaku/FIXIS (Red), Suzaku/PIN (Green) and Swift/BAT (Blue)) fitted with Ikeda model.

5. Opening angle vs. Inclination

The differences between these angles are very small in the most cases[13] (Figure 3). We interpret this an artifact caused by the presence of a strong unabsorbed reflection.

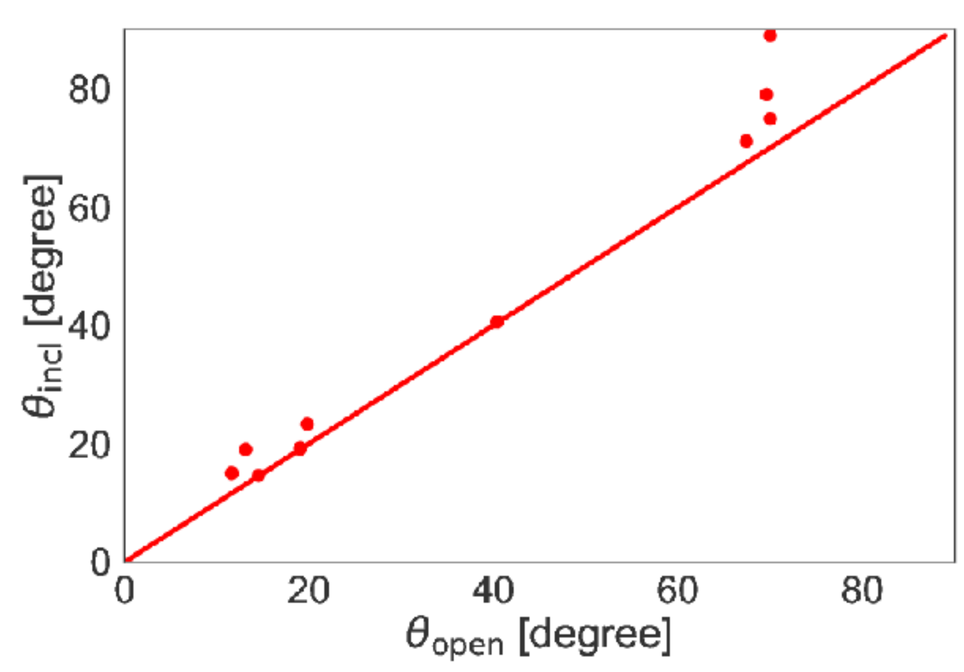

Figure 3. Correlation between the opening angle and the inclination angle of the torus. The red line shows the equal line.

6. log N_H vs. log f_{scat}

Most of our sample (10/12) show small scattering fractions (< 0.5%) (Figure 4). This implies that a majority of CTAGNs are buried in geometrically thick tori.

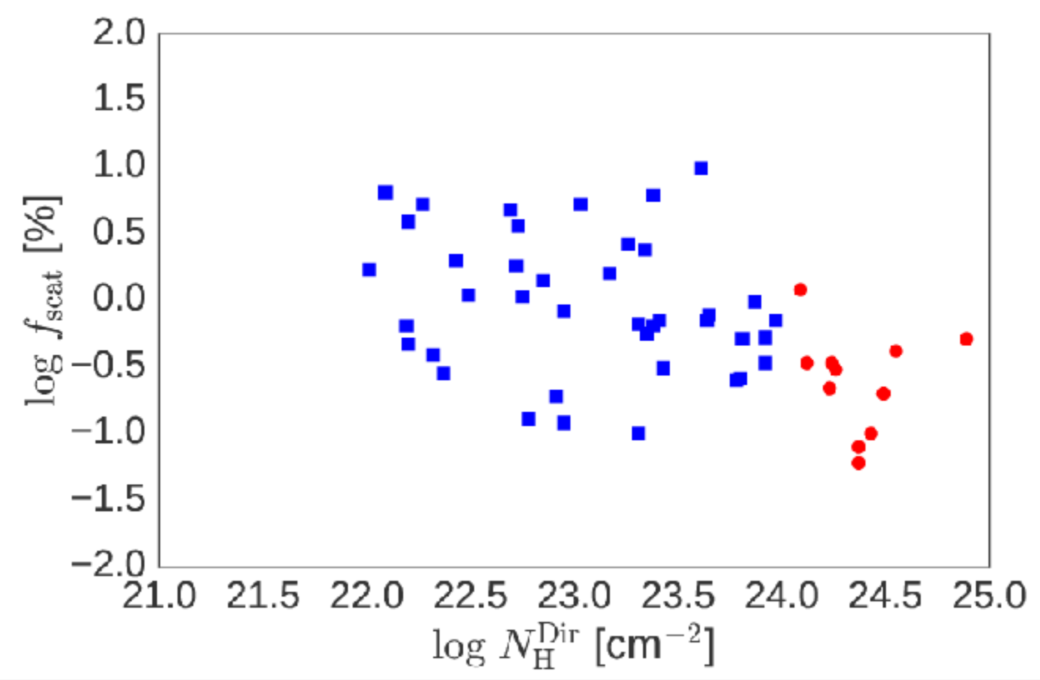

Figure 4. Correlation between the hydrogen column density and the scattered fraction. The blue squares show Compton-thin AGN[8].

7. X-ray vs. MIR Luminosities

Our sample generally follows the same correlation as for Compton-thin AGNs (Figure 5). More detailed comparison will be useful to reveal the geometry of their torus.

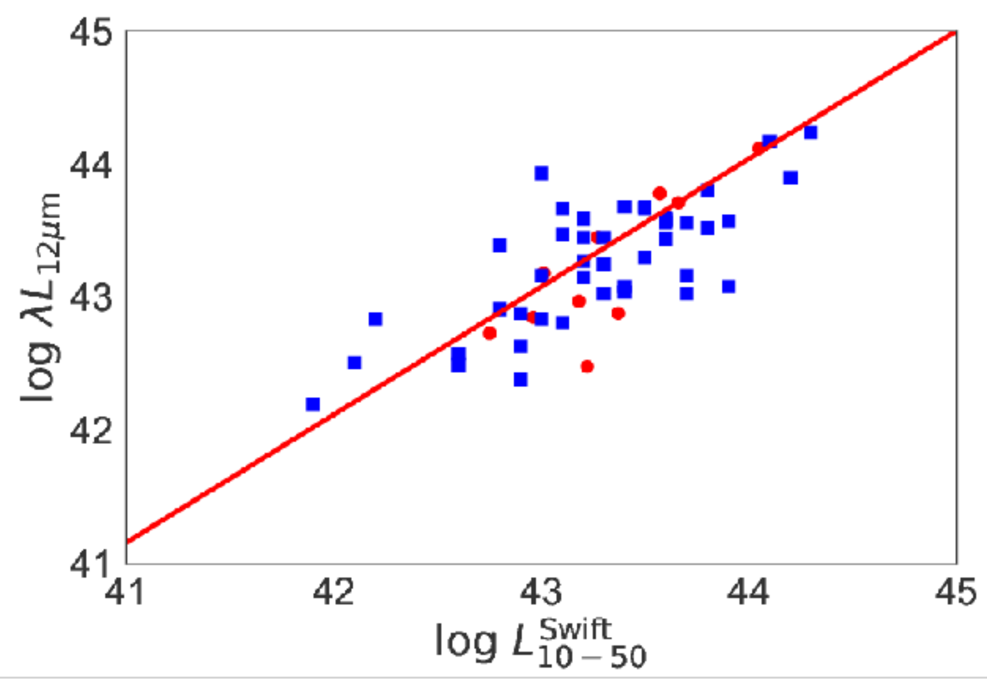

Figure 5. Correlation between the 10-50 keV and the 12 μm luminosities[01]. The red line is taken from Ichikawa et al. (2017)

8. Summary

1. Smooth torus models tend to give a geometrical solution where the line-of-sight is intercepted near the edge of the torus. We interpret this as evidence of clumpy tori.
2. Most of our sample (10/12) show small scattering fractions (<0.5%). This implies that a majority of CTAGNs are deeply buried in geometrically thick tori.
3. The overall results suggest that the nature of these CTAGNs can be understood as a smooth extension from Compton-thin AGNs with heavier obscuration: we find no evidence that they are distinct populations from less obscured AGNs.

9. Reference

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