Optical and X-ray Properties of the Swift BAT-detected AGN

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X-ray Astronomy 2009
The Swift BAT is an ‘all sky’ instrument – covering \( \approx 20\% \) of the sky at any one time and \( \approx 50\% \) of the sky each day when not triggering on GRBs.

- Sensitive from 14–195 keV
- Extensive follow-up of sources by the two other telescopes on SWIFT (UVOT and XRT) with relatively short exposures
‘Unbiased’ Survey

- All previous AGN surveys were biased (wrt obscuration)
- Much larger sample than HEAO-1 (and Integral) – 1st sensitive all sky hard x-ray survey in 28 years!
- BAT data provides first large unbiased sample of host galaxy properties
- Direct comparison with \( z \approx 1 \) Chandra and XMM surveys
  - Distribution of \( n_H \) values
  - Luminosity function
  - \( \log N - \log S \)
  - necessary for modeling x-ray background
9-month BAT Survey

- 153 AGN detected at $\geq 4.8\sigma$
- $F_{14-195\text{keV}} > \text{few} \times 10^{-11} \text{erg s}^{-1} \text{cm}^{-2}$
- $\langle z \rangle \approx 0.03$
- See Tueller et al. (2008)
- The Survey is continuing, with the completed 22 month (262 sources, ApJS, accepted) and on-going 36 month catalogs.
- Sensitivity is still scaling as $\sqrt{t}$
Collected X-ray properties from Swift XRT, ASCA, XMM-Newton, and Chandra

Sources selected:
- Detected with BAT as a $5\sigma$ or higher detection
- Optical counterpart clearly seen in DSS/2MASS images

See Winter et al. (2009)

(Left) XMM-Newton contours on DSS images.
Among Our Results ...

- Higher fraction of absorbed sources at low luminosity/accretion rate
- The average X-ray spectrum (0.6–10 keV) replicates the CXB slope of 1.4
- Very few Compton thick sources
Optical Study

- Covered 80% of the ‘Northern’ BAT sources (see Koss poster 7.35 for images)
- Spectra from archived SDSS observations (27), our own KPNO 2.1-m observations (40), and the literature (5)
- Half of the spectra show broad H-Balmer lines
Reddening Estimates

- No correlation between optical reddening and host inclination.
- No correlation between optical and X-ray extinction for narrow line sources.
- Unlike the results of Alonso-Herrero et al. (1997), most Sy 1s have more extinction in the optical than X-ray band.
Comparisons of Mass Determination Methods

- Reverberation mapping/H-β derived masses are well-correlated.
- 2MASS-derived/H-β derived masses are also well-correlated.
- Average mass of the Swift BAT-detected AGN: 
  \(< M/M_\odot > = 10^{7.87 \pm 0.66}\), consistent with previous studies (Woo & Urry, 2002)
Luminosity Distributions

Broad Line: \( \log L_{14-195\text{keV}} = 43.74, \log L_{\text{[OIII]}} = 41.79 \)

Narrow Line: Seyferts: \( \log L_{14-195\text{keV}} = 43.87, \log L_{\text{[OIII]}} = 41.55 \)
LINERs: \( \log L_{14-195\text{keV}} = 43.50, \log L_{\text{[OIII]}} = 40.73 \)
Others: \( \log L_{14-195\text{keV}} = 42.69, \log L_{\text{[OIII]}} = 40.33 \)
Slight correlations ($R^2 < 0.4$) are seen between \([\text{O III}]\) and BAT luminosities: $L_{\text{[O III]} (\text{corr})} \propto L_{\text{BAT}}^{1.16 \pm 0.24}$. There is a lot of scatter.

Agrees with Meléndez et al. (2008), in contrast to Heckman et al. (2005).
Best correlation ($R^2 = 0.6$) between the [O III] and soft X-ray flux for narrow line sources

Same seen in the XMM sample presented by Terashima (2009)
Host Galaxy Properties

- $D_n(4000)$: Old stars through the Ca II break
- $H\delta_A$: Young stars through H$\delta$ absorption
- Narrow Line sources are consistent with intermediate/old populations
- Broad Line sources have lower $H\delta$ EWs
- Low EWs ($< 0$) associated with very young populations of $< 0.1$ Gyr (Leitherer et al., 1999)
- But, see M. Koss’s poster (7.35)
Summary

- We have completed analyses of the X-ray (0.3–10 keV) and optical spectra of the Swift BAT-detected AGN in the 9-month catalog.
- Optical extinction is not from the host galaxy and is correlated with X-ray extinction for Sy 1s but not Sy 2s.
- Optically identified Seyferts have the same distributions of both [O III] λ5007Å and 14-195 keV luminosities for narrow and broad line sources. This is in agreement with the Unified Model.
- Correlations between [O III] λ5007Å and 14-195 keV luminosities are weak with much scatter. $L_{[[OIII]]}$ is not the best indicator of $L_{bol}$.
- Broad Line sources appear to have much younger stellar host populations than narrow line sources (based on Lick indices). This conflicts with the Unified Model?
Future and On-going Work

- Complete optical spectral properties from the 22-month catalog with coverage in the North (Koss) and South (Ueda)
- NIR imaging and spectroscopy (Koss)
- Fellowship program: A study of the Sy 1 warm absorber/outflow properties using X-ray, UV, and optical data
COS and GHRS spectra of an AGN outflow

COS observations achieved comparable S/N to the GHRS observations in about 1/10th the time with 10 times more spectral coverage! (credit: Brian Keeney, CASA)
COS and STIS

PKS0405−123

credit: Charles Danforth, CASA
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