Mini-Survey of SDSS [OIII] AGN with Swift:  
Testing the Hypothesis That L_{[OIII]} Traces AGN Luminosity  

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Introduction & Overview

The number of AGN and their luminosity distribution are crucial parameters for our understanding of the AGN phenomenon. Recent work (e.g., Fierrens et al. 2005) strongly suggests that every massive galaxy has a central black hole. However, most of these objects are not yet detected or have been very difficult to detect.

We are now in the era of large surveys, and the luminosity function (LF) of AGN has been estimated in various ways. In the X-ray band, Chandras and XMM surveys (e.g., Lauer et al. 2005; Heinz et al. 2005) and the IRAS Faint Source Survey (IRAS FSS) estimate the LF of AGN. The IRAS catalog contains about 100,000 AGN with a weak luminosity-dominant population, and a strong luminosity-dominant population with a strong break towards the AGN. This is seen for all types of AGN, but is stronger for the broad-line objects (e.g., Ulrich et al. 2004). In sharp contrast, the local LF of collapsed galaxies samples a far broader range of low-luminosity AGN, but no differences between narrow and broad-line objects (Haas et al. 2005).

If, as suggested, hard X-ray and optical emission line can both be fair indicators of AGN activity, it is important to first understand how the Hα line characteristics are if we hope to understand the apparent discrepancy in the LFs.

The SDSS and Swift

The Spectroscopic data from the Sloan Digital Sky Survey (SDSS) provides a rich resource for detecting & studying the properties of AGN. Several large & detailed studies have already been performed by the MPA/Leiden group led by Kauffmann.

We present the results from a simple comparison between two "classic" indicators of AGN activity - the luminosity of the [OIII] emission line ($L_{[OIII]}$) and that in the X-ray band ($L_x$). Unified schemes predict a simple linear relationship between $L_{[OIII]}$ and $L_x$ and such a relationship has been suggested in several studies (e.g., Kaserer et al. 2004; Heckman et al. 2004, Planke et al. 2006, Neuser et al. 2006, Panessa et al. 2008).

We recognize neither are perfect indicators. Indeed only a small fraction of X-ray-selected AGN are known to host Hα emitting regions, and the relation between Hα luminosity and X-ray luminosity is far from simple.

About Swift

Swift is a dedicated satellite to detect Gamma Ray Bursts and their afterglows. The initial detection of the GRB: is made with the BAT detector. A candidate source is then followed up with the UVOT (optical/UV) and XRT (0.3-10 keV) detectors. The typical Swift observation strategy for a GRB/afterglow consists of a cluster of snapshots. Depending on the evolution of the flux, the sensitivity of each instrument, and the required science, the data can also be strongly correlated to a monitoring campaign. The satellite monitors the same position for about an hour. When we trigger a new GRB or return to a position in the sun, Swift observes "blur" targets. A sample of sources is selected using all the observations made with the Swift XRT channel of Swift when observation with the Photon Counting mode which provides a spectral information.

Sample Selection

There are 18178 objects in the MPA/Leiden AGN catalog (http://maia.nao.ac.jp/qSGALSDSS/). These are cross-correlated with all Swift observations taken up to May 2007. This resulted in 3738 objects within the XRT field of view (20 arcmin). Further screening excluded a few objects with a problematic [OIII] measurement, and all objects < 1 arcmin PC mode. We also exclude all objects that do not satisfy the conservative emission line ratio criteria to be indicative of AGN activity. For example, Kewley et al. (2001), a radio brightness of $p$, and those > 10 arcmin from the XRT point source identification. Finally, we only include objects for which the sum of the exposure time exceeds 7 seconds. This gives a sample of 108 objects.

All data were calibrated and screened using the latest procedures, routine panels of the Swift software, and the latest calibration data for each observation. An image and an exposure time vignetting corrected map were calculated. All images and exposure maps related to a specific Swift object were summed. A sky background estimation algorithm was then run on the summed images. For all sources the final and upper limits were calculated using an extinction correction of the 90% of PSF, the exposure derived from the vignetting corrected exposure map and the background considering a source free near by the object. The detected or upper limits were converted to intrinsic flux by using a power law spectrum of 1.9 and the galactic absorption obtained from the Lacy/Lowell/Argentine/Sloan survey.

References

References

Examples

Fig. 2: Line diagram showing the Swift sample in the X-ray band. The other sources are plotted in black, and the other sources in the MPA/Leiden AGN catalog in grey.

Fig. 3: The L_{[OIII]} vs L_x plane for the sample. The 20 sources detected at 95% confidence are shown as the blue squares. Upper limits are shown for the others. The solid & dashed lines are the mean correlations for Seyfert 1s & 2s (respectively) found by Heckman et al. (2000).

Fig. 4: For Fig. 3, the sources judged to have both a strong nonermal continuum and strong [OIII] emission line are shown in red, and those with a weak non-thermal continuum & [OIII] line in blue. Intermediate objects are shown in black.

Fig. 5: The observed/predicted count rates assuming $L_{[OIII]}$ is drawn for 95% confidence, using the same color scheme as Fig. 3. The effect of additional absorption intrinsic to the AGN is shown by the dashed horizontal line.

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Fig. 7: The observed/predicted count rates assuming $L_{[OIII]}$ is drawn for 95% confidence, using the same color scheme as Fig. 3. The effect of additional absorption intrinsic to the AGN is shown by the dashed horizontal line.

Fig. 8: The observed/predicted count rates assuming $L_{[OIII]}$ is drawn for 95% confidence, using the same color scheme as Fig. 3. The effect of additional absorption intrinsic to the AGN is shown by the dashed horizontal line.

Fig. 9: The observed/predicted count rates assuming $L_{[OIII]}$ is drawn for 95% confidence, using the same color scheme as Fig. 3. The effect of additional absorption intrinsic to the AGN is shown by the dashed horizontal line.

Fig. 10: The observed/predicted count rates assuming $L_{[OIII]}$ is drawn for 95% confidence, using the same color scheme as Fig. 3. The effect of additional absorption intrinsic to the AGN is shown by the dashed horizontal line.

Caveat

We applied the values of $L_{[OIII]}$ used here as the (estimation-related) luminosities supplied in the MPA/Leiden catalog. We have not made any attempt to correct and filter the Swift spectra sources.

Conclusion & Future Work

Swift is proving to be a valuable resource for more than just GRB research. Here we have taken advantage of the isotropic distribution of GRBs to conduct a relatively unbiased study of the isotropic distribution of AGN.

We conclude, that $L_{[OIII]}$ alone is unlikely to provide a robust prediction of the X-ray luminosity in AGN and vice versa. At the current time, the limited parameter space investigated does tell us why this is.

We intend follow-up X-ray observations for the detected sources to determine the spectra.

We plan to extend this analysis so as to include more sources as both the Swift and SDSS catalogs grow. We also plan to extend our study to include other parameters associated with the AGN and host galaxy.

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