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., Faiferelli and Marr\textsuperscript{a} 2000) 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, Chandra and XMM surveys (e.g., Barger et al. 2005; Heinger et al. 2005) provide a good LF of the AGN population. These surveys show a strong luminosity-dependent evolution with a dramatic break towards the faint end (e.g., Steffen et al. 2004). In sharp contrast, the local LF of radio-selected galaxies shows no such break, and no differences between narrow and broad-line objects (Hao 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 Hubble characteristics are. 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 such studies have already been performed by the MPAGroup 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\textsubscript{[OIII]}), and that in the X-ray band (L\textsubscript{X}). Unified schemes predict a simple linear relationship between L\textsubscript{X} and L\textsubscript{[OIII]}, and such a relationship has been suggested in several studies (e.g., Knaar et al. 2004; Homan et al. 2006, Plak et al. 2006, Neister et al. 2008, Panessa et al. 2008).

We recognize neither are perfect indicators. Indeed one of our motivations was to study the scatter around any relationship. For L\textsubscript{[OIII]}, we have used data from a subset of the SDSS AGN catalog kindly made public by the MPA Group. For L\textsubscript{X}, we have used data collected with the XRT onboard Swift. Through both parallel and serendipitous observations, Swift provides a shallow but wide survey complementary to other X-ray surveys.

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. Follow-up optical imaging and spectra are obtained using the UVOT (optical/UV) and XRT (0.3-10 keV) detectors. The typical Swift observing 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 same object may be observed several times as for in a monitoring campaign. The satellite on average monitors the same position for about a month. While waiting for new GRBs or return to a position constraint by the Sun, Swift observes "blind" targets. This target of selected sources is selected using all the observations made with the XRT on the Swift when operation the Photon Counting mode which provides image and spectral information.

Sample Selection

There are 98 718 objects in the DR4 release of the MPAGroup AGN catalog (http://www.mpagroup.mpa-garching.mpg.de/AGN). These were cross-correlated with all Swift observations taken up to May 2007. This resulted in 3780 objects within the XRT field of view (30 arcmin). Further screening excludes a few objects with a problematic (OIII) measurement, and all exposure <10s in PC mode. We also exclude all objects that do not satisfy the conservative emission line ratio criteria to be indicative of AGN activity by Kewley et al. (2001), a redshift pk0.1, and those >10 km s\textsuperscript{-1} from the XRT nominal position. Finally, here we only include objects for which the sum of the exposure time is >100 s. This gives a sample of 108 objects.

All data were calibrated and screened using the latest procedures, routine patch of the Swift software and the latest calibration data. For each observation, an image and an exposure vignette corrected map were calculated. All images and exposure maps related to a specific SDSS object were summed. A skidding box detection algorithm was then run on the summed images. For all sources the flux (or upper limit) were calculated using an extinction correction corresponding to the 90% of PSF, the exposure derived from the vignette corrected exposure map and the background considering a source free near by the object. The detected or upper limit rates were converted into intrinsic flux by using a power law spectrum of 1.9 and the galactic absorption obtained from the Ladjew/Argenti/Sean survey.

Example Datasets

An example SDSS image, Swift XRT image and Swift spectrum from the sample, both summed from several observations. The location of the SDSS source is shown by the red dot, and clearly detected. The larger circles are used to estimate the background. The exposure map inset every image and black objects are taken into account during the analysis.

Caveat

Here we show the value of L\textsubscript{[OIII]} used here are the (attenuation-corrected) luminosities supplied in the MPAGroup catalog. We have not made any attempt to correct and fit the SDSS spectra colors.

References


Preliminary Results

We detect 20% of the sources in the sample. These sources cover the full range of L\textsubscript{[OIII]} of the sample population L\textsubscript{[OIII]}=10\textsuperscript{45}-10\textsuperscript{47} erg s\textsuperscript{-1}.

The detected sources exhibit a clear correlation between L\textsubscript{[OIII]} and L\textsubscript{X} in agreement with previous results (Fig. 3).

However there is ~1 order of magnitude scatter in the L\textsubscript{[OIII]} vs L\textsubscript{X} (Fig. 3).

Broadly speaking it appears our predicted values of L\textsubscript{X} were approximately 1 order of magnitude too high (Fig. 3).

The scatter in L\textsubscript{[OIII]} is likely to be much larger than a factor 10, given the tight upper limits on some of the objects (particularly apparent for the objects with L\textsubscript{[OIII]}<10\textsuperscript{45} erg s\textsuperscript{-1} (Fig. 3).

We have also detected (somewhat qualitatively at this stage) the strength of both the non-thermal continuum and [OIII] emission in each line in the sample.

We find no clear trend whereby the objects with very strong continuum & lines are preferentially detected (Fig. 4).

At this stage we find no clear evidence that the detected objects are correlated with any other parameters associated with the AGN or host galaxy (e.g., velocity dispersion, redshift, etc).

Likely Complications

- Intrinsic reddening and absorption in both the optical and X-ray band. The reddening can be difficult to model for a variety of reasons. Regarding the latter, there are generally too few counts in the current Swift data to allow meaningful spectral analysis in the X-ray band (but see Fig. 5).

- Despite our conservative selection criteria, it is possible that starforming regions & LINERs contribute to L\textsubscript{[OIII]} in some objects (see Fig. 2).

- Some of the variance in L\textsubscript{[OIII]} could be due to geometrical considerations associated with non-spherical and/or clumpy (OIII) emission regions.

- There appears to be a difference in the L\textsubscript{[OIII]}/L\textsubscript{X} relationship between Seyfert 1s & Seyfert 2s (e.g., Homan et al. 2005). We have not distinguished between these two classes separately.

- Many AGN are known to exhibit spectral complexity in the X-ray band (such as intrinsic photoionized emission lines in the soft band, "Compton humps," etc.), rather than the simple powerlaw assumed in our analysis.

- Time-variability affects the calculated value of L\textsubscript{X} is an "instantaneous" measurement, but L\textsubscript{[OIII]} represents the average (integrated) AGN activity over the previous ~10\textsuperscript{7} years.

- The automated extraction routine may for some of the SDSS data be caused by the weakness of the lines in some objects (e.g., the right-hands example shown below).

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\textsubscript{[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 archives grow. We also plan to extend our study to include other parameters associated with the AGN and host galaxy.