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

L. Angelini\textsuperscript{a, b}, I. M. George\textsuperscript{a, d}, J. Hill\textsuperscript{c}, C. A. Padgett\textsuperscript{d}, R. F. Mushotzky\textsuperscript{a}

\textsuperscript{a}NASA/Goddard Space Flight Center, Greenbelt, MD 20771, USA. \textsuperscript{b}University of Maryland Baltimore County, Baltimore, MD 21250, USA. 
\textsuperscript{c}Universities Space Research Association, Columbia, MD 21044, USA. \textsuperscript{d}R.S. Information Systems, McLean, VA 22102, USA.

Introduction & Overview

The number of AGN and their luminosity distribution are crucial parameters for our understanding of the AGN phenomena. Recent work (e.g., Ferrarese and Merritt 2000) strongly suggests every massive galaxy has a central black hole. However, most of these objects either are not radiating 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, Chiu et al. (2006), Bauer et al. (2002), Hoare et al. (2000) have revisited the LF of [OIII]-selected AGN shows a strong luminosity-dependent evolution with a dramatic break towards low \(L_{\text{r}}\). This is seen for all types of AGN, but is stronger for the broad-line objects (e.g., Steiner et al. 2004). In sharp contrast, the local LF of [OIII]-detected samples shows no such break and no differences between narrow and broad-line objects (Hirose et al. 2009).

If, as been suggested, hard X-ray and optical emission line data can both be far more indicative of AGN luminosity. It is important to first understand how different these luminosities are before we have a clear idea of 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 and studying the properties of AGN. Several large scale studies have already been performed by the MPA/JHU group led by Kaufmann et al. (2011).

We present the results from a simple comparison between two "classical" indicators of AGN activity: the luminosity of the [OIII] emission line (\(L_{\text{r}}\)) and the X-ray luminosity in the X-ray band (\(L_{\text{X}}\)). The X-ray band (\(L_{\text{X}}\)) limits scheme projects a simple linear relationship between \(L_{\text{r}}\) and \(L_{\text{X}}\) and such a relationship has been suggested in several studies (e.g., Kaarman et al. 2004; Heckman et al. 2005; Pail et al. 2006; Netzer et al. 2006; Panessa et al. 2006). We recognize neither are perfect indicators. Indeed one of our motivations was to study the scatter around any relationship. For \(L_{\text{r}}\), we have used data from a subset of SDSS AGN kindly made public by the MPA Team. For \(L_{\text{X}}\) we have used Chandra X-ray Observatory (CXO) data collected by the XRT onboard Swift. Through both pointed and serendipitous observations, Swift provides a shallow but wide survey complementary to X-ray surveys.

About Swift

Swift is a dedicated satellite to detect Gamma Ray Bursts and their afterglows. The initial goal of the GRB is made with the BAT detector. The satellite then swipes and starts observing the U/OT (Optical/UV) and XRT (0.1-10) keV detectors. The typical Swift observing strategy for a GRB is an average of a cluster of smaller gridds. Depending on the evolution of the flux, the availability of instruments, and the chosen distance, the strategy may be observed several times as fast as filtering in a monitoring. The satellite can average monitoring the same position for about a month. While waiting for new GRBs or return to a position contained by the sun, Swift observes "Kia" targets. The sample of sources is selected using all the observations made on the XRT when operating in the Photon Counting mode which provides image and spectral information.

Sample Selection

There are 1070 XRT objects in the first release of the MPA/JHU AGN catalog (http://www.mpacarnegie.org/SDSS). These were cross matched to the SDSS DR4 objects taken up to the end of 2007. This resulted in 3708 objects within the XRT field of view (20 arcmin radius). Further screening excludes a few objects with a problematic [OIII] measurement, and all objects with a flux below 3x10^-17 erg s^{-1} cm^{-2} in any of the XRT bands. Finally, from the 1070 objects, we retained only objects for which the sum of the exposures in all observations is > 24.84s. This gives a sample of 105 objects and a total of 358 observations.

Preliminary Results

We detected 20/108 of the sources in the sample

- These sources cover the full range of [OIII] for the sample population (\(L_{\text{r}}\) = 10^{40}-10^{46} erg/s).
- The detected sources exhibit a clear correlation between \(L_{\text{r}}\) and \(L_{\text{X}}\) agreement with previous results.
- Plotting the 

- Broadly speaking it appears our predicted values of \(L_{\text{r}}\) were approximately 1 order of magnitude too high (Fig. 5).
- The scatter in \(L_{\text{r}}\) is likely to be much larger than a factor 10,
- The sample in \(L_{\text{r}}\) is correlated with any other parameter (e.g., Heiskanen et al. 2003).

Likely Complications

- Intrinsically reddening and absorption in both the optical and X-ray band.
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We have also detected (somewhat qualitatively at this stage) the strength of both the non-thermal continuum and [OIII] emission line in each object in the sample.

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

Final Stage

- We find no clear evidence that the detected objects are correlated with any other parameter associated with the AGN host galaxy (e.g., radio-loud, starburst, IR, etc.).

Conclusion & Future Work

Swift is proving to be a valuable resource for more than just GRB research. Here we have taken advantage of the few objects that were detected in the current Swift data to allow meaningful analysis of the X-ray band [see Figs. 5 & 6.]

- The presence of AGN may be due to geometrical considerations associated with non-spherical and/or clumpy [OIII] emission regions.
- There may exist a correlation between the [OIII] relationship between Swift and X-ray sources (e.g., Heiskanen et al. 2003. We have not distinguished these two classes so far.
- Many AGN are known to exhibit spectral complexity in the X-ray band (such as intense photometric emission lines in the soft band, "Compton humps", etc.), rather than the simple powerlaw assumed here.
- For a variable value of \(L_{\text{r}}\), there is a range of variances.
- The automated extinction correction necessary for the production of the SDSS catalog may be enhanced by the weakness of the lines in some objects (e.g., the right-hand example shown below).

References