



WPVS 007 and Mkn 335: The link between NLS1s and BAL QSOs

Dirk Grupe (PSU), Stefanie Komossa, Karen Leighly (Univ. of Oklahoma)



Abstract: The X-ray transient AGN WPVS 007 was an X-ray bright source during the ROSAT All-Sky Survey, but basically disappeared from the X-ray sky for almost two decades. FUSE observations in 2003 revealed the nature of this disappearance: strong absorption. FUSE spectra showed deep absorption line troughs in the UV spectrum of WPVS 007. These findings make this AGN a direct link between NLS1s and Broad Absorption Line QSOs which are both thought to be high L/Edd AGN. In the recent year Swift was able to detect WPVS 007 in X-ray at relatively bright states several times, suggesting that the absorber may have started to disappear. In some ways similar is the NLS1 Mkn 335 which has been observed in X-ray in a bright state over decades, but was found by Swift in an extremely low state in May 2007. Our XMM observation from June 2009 shows the presence of a strong ionized partial covering absorber in the X-ray data of Mkn 335.

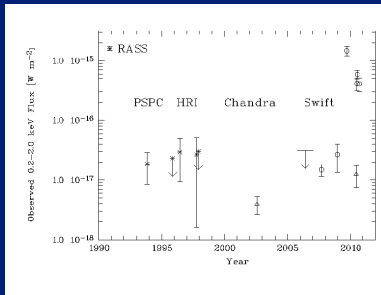


Figure 1: Long-term 0.2-2.0 keV X-ray flux light curve of WPVS 007.

III. X-ray variability of WPVS 007

Figure 1 displays the long-term 0.2-2.0 keV flux light curve of WPVS 007. This NLS1 has shown the most dramatic decrease of any AGN in X-rays by a factor of about 400 between the ROSAT All-Sky Survey observation in 1990 and a pointed ROSAT observation in 1993. Follow up observations with ROSAT and Chandra confirmed this extreme low state. We were finally able to detect it again in X-ray with Swift in a 50 ks observation in September 2007. This observation also revealed for the first time hard X-ray photons from this AGN that had the steepest X-ray spectrum of any AGN during the RASS. The photon distribution of this observation could be fitted by a power law model with a strong partial covering absorber (Grupe et al. 2008b).

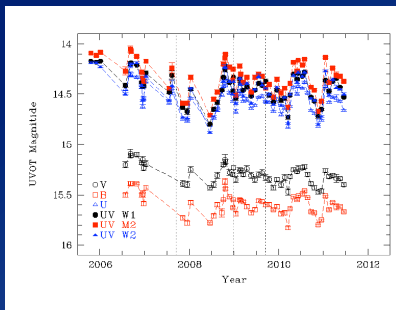


Figure 3: Swift UVOT light curves of WPVS 007.

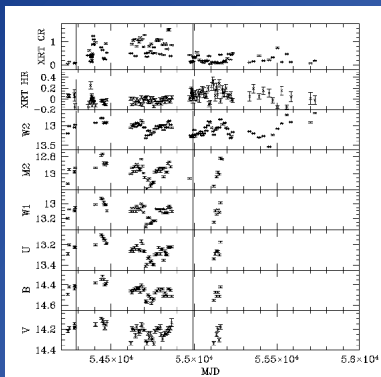


Figure 4: Swift XRT and UVOT light curves of Mkn 335 starting in May 2007 when it was discovered in an extremely low X-ray flux state.

I. Introduction: Narrow Line Seyfert 1 galaxies are the most variable non-beamed AGN in X-rays. Typically AGN vary by factors of about three even within days. However, the NLS1 WPVS 007 (Grupe et al. 1995) is a unique X-ray transient AGN: While typically X-ray transients are associated with an X-ray outburst caused by a dramatic increase in the accretion rate, the situation in WPVS 007 is different. Here the AGN was bright during the ROSAT All-Sky Survey, but then basically disappeared from the X-ray sky ever since. The cause of this transience had been a mystery for more than a decade, but observations with FUSE revealed that it is a strong absorber that causes the AGN to be so X-ray faint (Leighly et al. 2009). Somewhat similar is the NLS1 Mkn 335. This AGN has been known to be X-ray bright since it was first detected by UHURU. However, when we observed it in May 2007 with Swift, we discovered it in an extremely low X-ray flux state. A follow-up observation with XMM showed that one possible explanation for this low state is a strong partial covering absorber.

II. Observations of WPVS 007 and Mkn 335.

We have been monitoring WPVS 007 with Swift since October 2005 (Grupe et al. 2007a, 2008b) typically once per month for 2 ks with the XRT and UVOT in all 6 filters. This is a still going monitoring campaign of which the exposure time has been increased to 5 ks per observation since April 2010. Mkn 335 was observed as part of a Swift fillin program to study the spectral energy distributions of AGN (Grupe et al. 2010). After it was discovered to be in an extreme low X-ray flux state we have monitored it for at least once per month except for the three months when it is in sun-constraint.

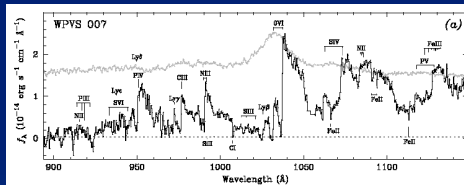


Figure 2: FUSE spectrum of WPVS 007 (Leighly et al. 2009). The grey spectrum is the HSTQSO composite spectrum by Zheng et al. (1997).

IV. WPVS 007: The link between NLS1s and Broad Absorption Line QSOs

The dramatic decrease in X-ray by a factor of more than 400 between 1990 and 1993 was puzzling. HST UV spectra taken in 1996 (Goodrich 2000) showed mini Broad Absorption Lines (BALs) suggesting outflowing absorbing matter. However, when FUSE observed WPVS 007 in the FUV in 2003 it became clear what is going on in this AGN: This FUV spectrum as shown in Figure 2 revealed very strong BALs, discovering the emergence of BALs for the first time in a low-luminosity AGN (Leighly et al. 2009). It has been suggested by e.g. Brandt & Gallagher (2000) and Boroson (2002) that NLS1s and BAL QSOs are closely related, being both AGN that operate both at high L/L_{Edd} ratios. WPVS 007 is the link between these two AGN classes.

V. Swift UVOT light curves of WPVS 007

Figure 3 displays the Swift UVOT light curves of WPVS 007 starting in October 2005 to March 2011. WPVS 007 is highly variable in the UV with up to 0.7 mag in W2. Typically NLS1s only show UV variability in the order of 0.3 mag (Grupe et al. 2010).

We will still continue monitoring WPVS 007 in the future with Swift in order to catch it when it will be in an X-ray high flux state again and how this flux state relates to the UV emission.

VI. Swift and XMM observations of Mkn 335:

The NLS1 Mkn 335 has been known to be an X-ray bright AGN since its first detection in X-rays by UHURU, except during an EXOSAT observation in 1983 (Pounds et al. 1987). When we observed it with Swift as part of our fillin program to study the SEDs of AGN (Grupe et al. 2010) we discovered it in an extreme X-ray low flux state (Grupe et al. 2007b). We have monitored Mkn 335 with Swift on a monthly basis and found it to be highly variable in X-rays as well as in the UV (Figure 4). However, although it has shown an episode of being in a relatively high state, for most of the time it has remained in a low X-ray flux state. So far this low state continues up to now with the most recent observation on 2011 May 20.

Our XMM observation from July 2007 (Figure 5) showed that the X-ray spectrum can be fitted by a partial covering absorber (Grupe et al. 2008a). We had another XMM observation in June 2009 which suggests that the partial covering absorber has become ionized. Alternatively the X-ray spectra can also be fitted by reflection models.

The dramatic drop in X-ray flux by a factor of more than 30 between 2006 and 2007 (Grupe et al. 2007b) and the possible explanation of the X-ray spectrum with a partial covering absorber may suggest that we see a similar process in Mkn 335 that we see in WPVS 007.

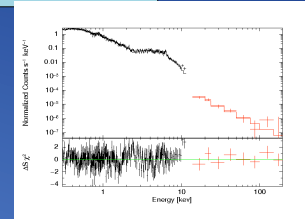


Figure 5: Combined XMM, XRT, and Swift BAT spectra from the 2007 XMM observation and the 22 months BAT survey (Tueller et al. 2010).

References:

- Boroson, T.A., 2002, ApJ, 565, 78
- Brandt, W.N., & Gallagher, 2000, New AR 44, 461
- Goodrich, R.W., 2000, New AR 44, 519
- Grupe, D., et al., 1995, A&A, 300, L21
- Grupe, D., et al., 2007a, AJ, 133, 1988
- Grupe, D., Komossa, S., & Gallo, L., 2007b, ApJ, 688, L111
- Grupe, D., et al., 2008a, ApJ, 681, 982
- Grupe, D., Leighly, K.M., & Komossa, S., 2008b, AJ, 136, 2343
- Grupe, D., et al., 2010, ApJS, 187, 64
- Leighly, K.M., et al., 2009, ApJ, 701, 176
- Pounds, K.A., et al., 1987, MNRAS, 224, 443
- Tueller, J., et al., 2010, ApJS, 186, 378

Acknowledgments: Swift is supported at Penn State by NASA contract NASS-00136. This research has been supported by NASA contracts NNX09AP50G, NNX08AT25G, NNX10AAF48G, NNX10AK85G, and NNX09AN12G.