SWIFT MULTI-WAVELENGTH OBSERVATIONS OF NGC5548 : A SEYFERT 1 IN A VEGETATIVE LOW-STATE.

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ABSTRACT

Swift observed the archetypal Seyfert 1 galaxy NGC5548 during April-May 2005, as an integral part of a co-ordinated ground- and space-based multi-wavelength monitoring campaign aimed at measuring the interband continuum time-delays, and thereby the mass accretion rate in a small sample of nearby, low-luminosity, radio-quiet AGN. Here we report on the X-ray/ultra-violet/optical temporal and spectral characteristics of this source as observed by *Swift* during the course of this campaign.

Key words: NGC5548; multi-wavelength monitoring.

1. NGC5548 : THE ARCHETYPAL SEYFERT 1

NGC5548 is by far the best observed of all nearby AGN. In the ultra-violet and optical bands NGC5548 displays highly correlated continuum and broad emission-line variations which may be used to map the spatial distribution and physical properties of the emission-line gas on size scales ($<$ a few microarcseconds) currently unachievable by more conventional means (ie. direct imaging). In the 3-10 keV band, the high soft-state spectrum of NGC5548 can be fitted with an absorbed power-law of photon index $\Gamma = 1.75$ together with reflection (Pounds et al. 2003) and a weak narrow FeKα emission-line (EW$\sim$60 eV). Below 0.7 keV the X-ray spectrum shows a clear soft-excess which can be best described as either Comptonised thermal emission or enhanced reflection from a highly ionised accretion disc. The X-ray spectral variations appear to be correlated with continuum flux, with the X-ray spectrum being significantly softer when brighter.

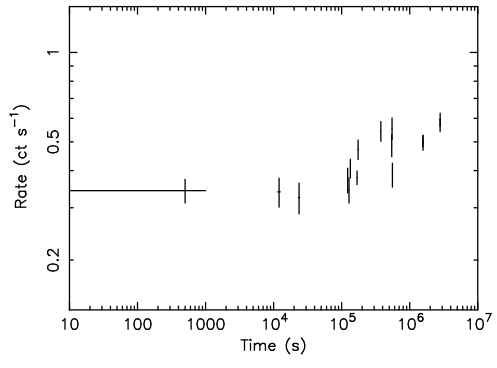

Figure 1. XRT 0.2-10.0 keV PC mode light-curve for NGC5548.

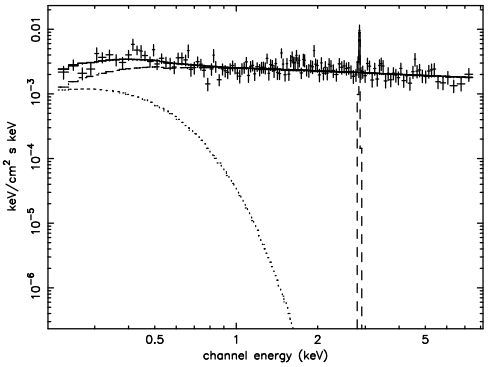

Figure 2. XRT PC mode spectrum of NGC5548. The spectrum is well-fit by an absorbed power-law $\Gamma = 1.2$, $n_{\rm H} = 1.69 \times 10^{20}$ cm^{-2}, a soft excess which we model as a simple blackbody with temperature $kT = 0.1$ keV and an emission-line at 2.85 keV.

1.1. Swift XRT monitoring of NGC5548

Swift XRT observed NGC5548 on 14 separate occasions from April 8th to May 10th 2005, with a total on-source exposure of 13 ks. The high count rate, a result of numerous hot pixels, meant that some source on-time was lost due to mode switching (Hill et al. 2004), with the majority of the observations in Photon Counting (PC) mode. The cleaned event lists contain a total on-source exposure of 9.385 ks (PC) and 3.646 ks in Windowed Timing (WT) mode. Figure 1 shows the XRT PC mode 0.2-10 keV light-curve of NGC5548. For clarity all counts in a single

observation have been grouped into one bin. The source shows significant variability on timescales of a few hundred seconds, with a mean observed count rate of 0.3 ct s^{-1} and variance 0.44 ct s^{-1}. Figure 2 shows the best-fit model to the PC mode data. The spectrum is well-fit by a single absorbed power-law with photon index $\Gamma = 1.2$, $n_{\rm H}$ fixed at the Galactic value of 1.69×10^{20} cm^{-2}, a soft excess which we model as a blackbody with temperature $kT = 0.1$ keV and an as yet unidentified emission-line at 2.85 keV. We find a mean 2.0-10.0 keV unabsorbed flux of 1.6×10^{-11} erg cm^{-2} s^{-1}, a factor of 3 lower that that reported in Pounds et al. (2003) for *XMM*/EPIC MOS observations of this source.

2. SWIFT UVOT GRISM OBSERVATIONS

Swift UVOT grism observations of NGC5548 were taken on 14 separate occasions constituting 8 distinct epochs with a total on-source exposure time of 12 ks (U-grism) and 7 ks (V-grism). The grism observations were processed to remove the modulo-8 fixed pattern noise, cleaned of hot pixels and flat-fielded. Source and background spectra were extracted using the widest possible extraction slit (>35 pixels) avoiding where possible contamination by other sources in the field. For the effective area curves we use those derived from model fits to white dwarf spectra (Wayne Landsman, private communication) taken as part of the UVOT calibration phase verification. We note that individual spectra are affected by 2nd order contamination at wavelengths >3600Å (U-grism), >5600Å (V-grism).

Figure 3 shows the combined XRT/UVOT U-grism multi-wavelength spectrum for NGC5548.

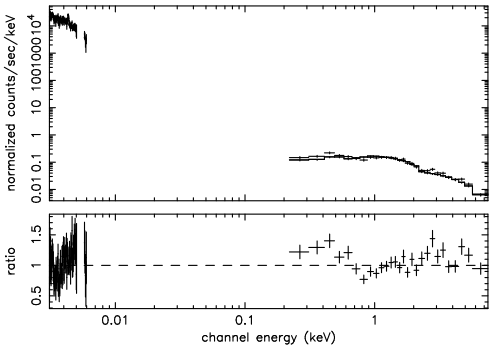

Figure 3. The combined XRT/UVOT U-grism spectrum of NGC5548. The V-grism observations await further calibration of the effective area file.

The *Swift* combined multi-wavelength spectrum of NGC5548 is markedly different from that reported in Walter et al. (1993), from simultaneous IUE, GINGA and ROSAT observations, with a considerably harder X-ray photon index ($\Gamma = 1.2$ c.f. 1.9). The X-ray spectrum is also much harder than that reported in Pounds et al. (2003; $\Gamma = 1.75$). This startling result suggests that

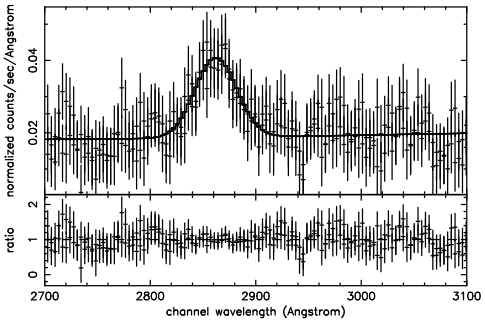

Figure 4. A fit to the continuum and MgIIλ2800Å emission-line of NGC5548. The line remains broad (FWHM=4610 km s^{-1}).

NGC5548 has undergone spectral evolution from a high soft-state to a low hard-state. State changes of this nature have been reported for other sources, notably the NLS1 NGC4051 (Pounds et al. 2004). Possible causes include a reduction in the mass accretion rate, and/or obscuration of the steep powerlaw X-ray continuum by intervening gas.

We note that, while the X-ray continuum is relatively weak, the strong UV low ionisation emission-line MgIIλ2800Å remains broad with a FWHM of 44.6Å equivalent to a velocity of 4610 km s^{-1}, broader than that measured for the narrow line in the 1992 *HST*/FOS low-state spectrum (Crenshaw et al. 1993), and similar in width to the semi-broad MgII component reported by Goad et al. (1998). We further note that the MgII line EW (58.2Å) is similar to that derived for the semi-broad component (60.9Å ; Goad et al. 1998). Interestingly, the broad UV emission-lines of Lyα and CIVλ1550Å are totally absent from an HST/STIS spectrum of NGC5548 taken in early 2004, when the UV continuum was in an historical low-state. In fact the broad lines are so weak that the narrow CIV doublet is clearly resolved. If the frequency of changes in state are related to black hole mass and/or accretion rate, then it is entirely possible that NGC5548 will remain in this vegetative low-state for many years.

ACKNOWLEDGMENTS

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REFERENCES

Crenshaw, D.M. Boggess, A. and Wu, Chi-Chao 1993, ApJ 416, L67.

Goad, M.R. and Koratkar, A. 1998, ApJ 495, 718.

Pounds, K. A.; Reeves, J. N.; King, A. R.; Page, K. L. 2004, MNRAS 350, 10.

Pounds, K. A.; Reeves, J. N.; Page, K. L.; Edelson, R.; Matt, G.; Perola, G. C. 2003, MNRAS 341, 953.

Walter, R.; Fink, H. H. 1993 A&A 274, 105.