Advantages of XMM for the Study of NLS1

Th. Boller
Max–Planck–Institut für Extraterrestrische Physik, Giessenbachstraße, 85740 Garching, Germany

W.N. Brandt
The Pennsylvania State University, 525 Davey Lab, University Park, PA 16802, USA

A.C. Fabian
Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, UK

ABSTRACT

Active Galactic Nuclei (AGN) are divided according to their optical line properties into subclasses, like Seyfert 1 galaxies, Narrow-Line Seyfert 1 galaxies (NLS1), Seyfert 2 galaxies, LINERs, and BL Lacs. NLS1 are an interesting group of Seyfert 1s showing Balmer line Full Width at Half Maximum much smaller (500–1500 km s^{-1}) than typically observed (1500–10000 km s^{-1}). ROSAT and ASCA have shown many NLS1 to have remarkable X-ray spectral and timing properties. Here we briefly review these properties and summarize the advantages of XMM for the study of NLS1.

1. Broad-band continuum properties

ROSAT and ASCA have shown that many NLS1 have remarkable X-ray properties. The ROSAT spectra of NLS1 generally have strong soft X-ray excess components compared to Seyfert 1 galaxies with broader optical permitted lines. When simple power-law models are fit to the data, photon indices reach values up to about 5, much higher than the photon indices of about 2.4 seen in Seyfert 1s. A clear anticorrelation is found between the ROSAT spectral softness and the widths of the optical Balmer lines (Boller, Brandt & Fink 1996; see Figure 1). The 2–10 keV continua of ultrasoft NLS1 show a similar trend of increasing steepness with decreasing Hβ line width (see Figure 2) as shown by Brandt, Mathur & Elvis (1997). As a result, the broad band X-ray spectra of NLS1 often resemble those of Galactic black hole candidates accreting in their ultrasoft high states.

These results are remarkable as the X-ray spectra of Seyfert galaxies are formed within only a few Schwarzschild radii of their black holes, while the optical permitted lines are formed in a significantly larger region. NLS1 thus provide a unique benchmark for understanding the relationship between the X-ray properties of Seyferts and the widths of their optical emission lines. It has been suggested that NLS1 are those Seyfert 1s accreting at relatively high fractions of the Eddington rate (e.g. Brandt & Boller 1998).

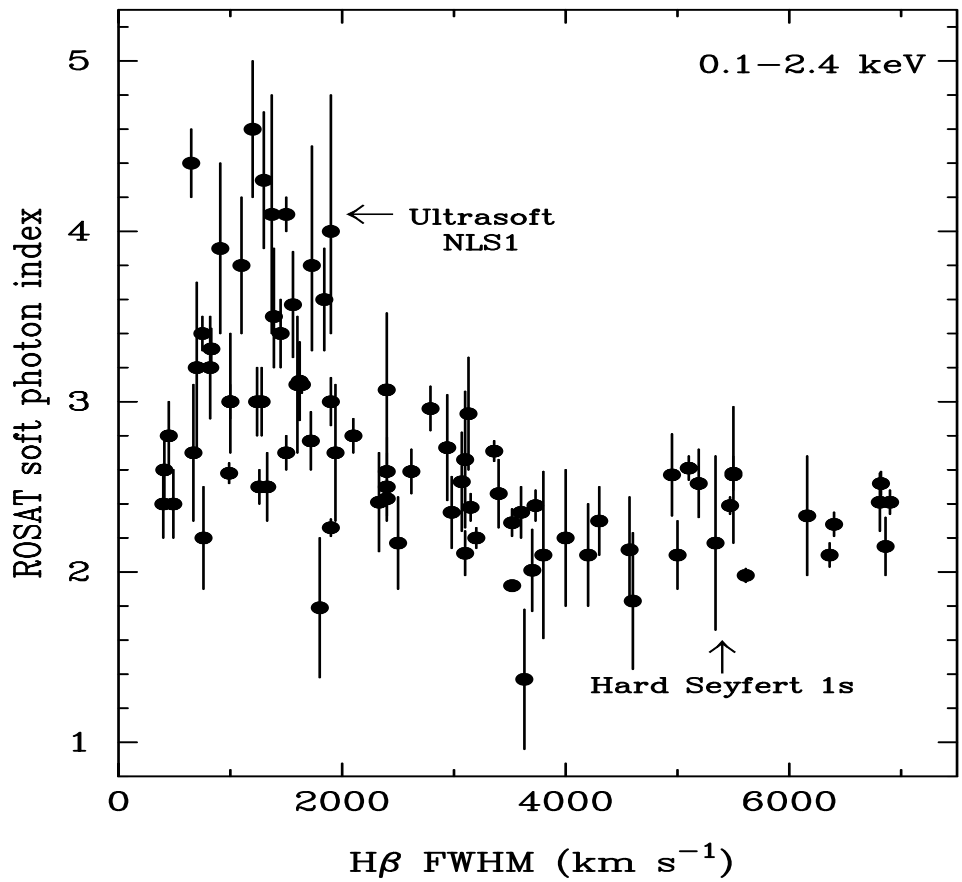

Fig. 1.— Relation between the soft (0.1–2.4 keV) spectral steepness and the FWHM of the Hβ line. The NLS1 are those discussed in Boller, Brandt & Fink (1996). Objects with FWHM of the Hβ line larger than 2000 $\mathrm{km \cdot s^{-1}}$ are from ROSAT observations of broad-line Seyfert 1 galaxies (e.g. Walter & Fink 1993). A large diversity in the spectral steepness is found for NLS1.

2. X-ray timing properties

Ultrasoft NLS1 can also show remarkably rapid and large-amplitude X-ray variability. One spectacular object, IRAS 13224–3809, shows persistent giant-amplitude (factors of 35–60) variability events within a 30-day ROSAT HRI observation (see Figure 3; Boller et al. 1997). The timescales for such giant variations found before in a few other AGN are of the order of a few years. The variability is also nonlinear, which suggests that it cannot be physically modeled in terms of the superposition of a large number of independent emission regions. ROSAT HRI monitoring observations of the luminous narrow-line quasar PHL 1092 obtained in July 1997 resulted in a similar light curve with multiple rapid and large-amplitude events (Brandt et al. 1998). In this case, the maximum observed variability amplitude was a factor of ≈ 14, and the most rapid variability event appears to imply an extremely large radiative efficiency of $\eta > 0.62 \pm 0.13$. Such a high efficiency may suggest relativistic X-ray flux boosting in this radio-quiet quasar.

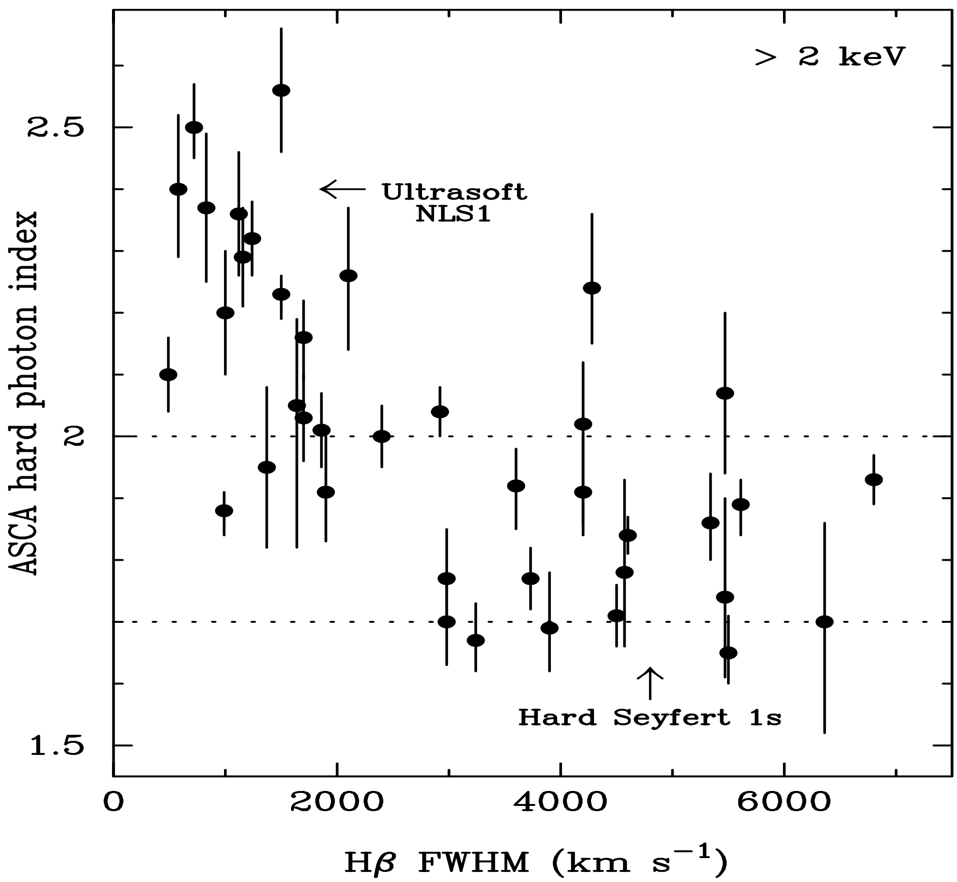

Fig. 2.— Relation between the 2–10 keV spectral steepness and the FWHM of the Hβ line (Brandt, Mathur & Elvis 1997). This trend is similar to that shown in Figure 1, but now only the underlying power law contributes to the fit. Note that the amplitude of the effect is significantly weaker than in Figure 1.

3. X-ray observations of NLS1 with XMM

We have proposed to continue our successful X-ray studies of ultrasoft NLS1 by making XMM observations of some of the most interesting members of this class. The broad band, large effective area, and high spectral resolution of XMM will allow the best X-ray studies of NLS1 to date. We will study their soft and hard X-ray continua, their spectral features, and their strong flux and spectral variability. XMM spectra will allow **(1)** precision fitting of the soft X-ray excess and hard X-ray power law, **(2)** studies of broad and ionized iron K line emission, **(3)** studies of ionized gas along the line of sight, and **(4)** measurements of the Compton reflection continuum. XMM light curves will allow **(1)** uninterrupted studies of rapid and nonlinear X-ray variability, **(2)** power spectrum analyses, **(3)** searches for simultaneous X-ray and optical variability, and **(4)** measurements of spectral variability.

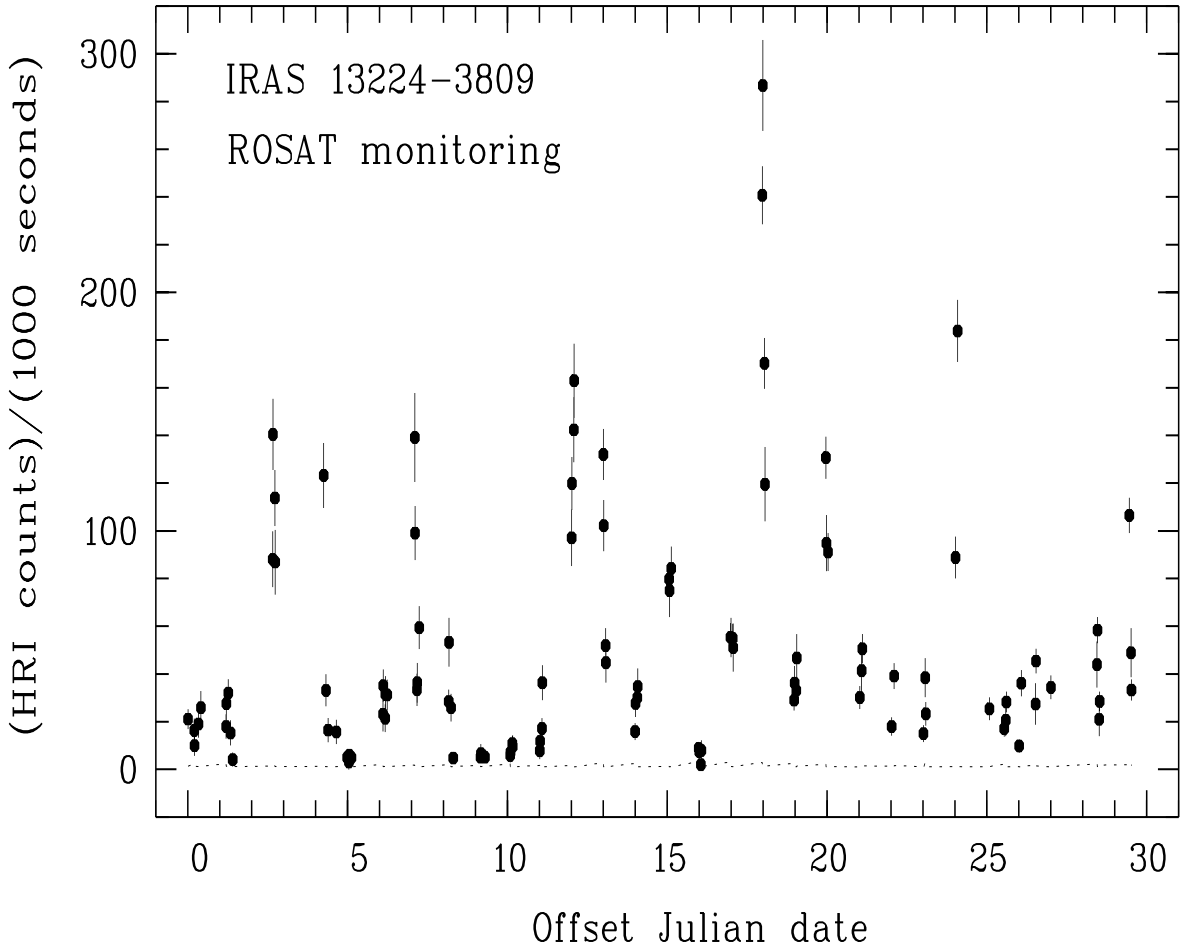

Fig. 3.— Light curve from a ROSAT HRI monitoring campaign on the ultrasoft NLS1 IRAS 13224–3809. The campaign occurred between 1996 January 11 and February 9. A detailed discussion can be found in Boller et al. (1997).

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