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Evidence of coronal flaring in narrow-line Seyfert 1 galaxies

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Abstract. High-energy ($E > 2$ keV) continuum flaring is detected in two narrow-line Seyfert 1 galaxies (I Zw 1 and NAB 0205+024), consistent with occurring in a hot corona distinct from the accretion disc. The flare in I Zw 1 is accompanied by an increase in the amount of gravitationally redshifted reflected emission coming from the accretion disc. This indicates that the high-energy continuum component is compact and located close to the black hole, and could possibly be the base of an aborted jet.

Key words. galaxies: active – galaxies: nuclei – quasars: individual: I Zw 1, NAB 0205+024 – X-ray: galaxies

1. Introduction

X-ray flaring is detected in the 2002 *XMM-Newton* observations of two narrow-line Seyfert 1 galaxies (NLS1s): I Zw 1 (Gallo et al. 2004a) and NAB 0205+024 (Gallo et al. 2004b). The data indicate that: 1) the flares are concentrated at energies above $\sim$ 2 keV; 2) spectral variability during the flares is consistent with a power-law component that varies in normalisation, but not necessarily in slope; 3) in both objects, a gravitationally redshifted reflection component (i.e. a broadened and redshifted Fe Kα emission line) is seen. In the case of I Zw 1 this component is shown to immediately brighten in response to the high-energy continuum flare (Gallo et al. 2007a).

2. High-energy X-ray flaring

During the 2002 *XMM-Newton* observations of the NLS1s, I Zw 1 and NAB 0205+024, rapid ($<$ 5 ks), modest amplitude ($\sim$ 100 per cent) X-ray flaring was detected (Fig. 1). The flares were concentrated at high-energies ($E >$ 2 keV) and shown to induce spectral variability (Fig. 2). The spectral variability was consistent with the power-law component changing in normalisation, but not necessarily in shape.

3. Spectral signatures

During the observation of NAB 0205+024 a broad component in the spectrum (Fig.3) was identified as redshifted Fe Kα emission arising from reflection of high-energy photons in the accretion disc (Gallo et al. 2004b). The bulk of the emission is redward of 6.4 keV suggesting that the emission line was produced in a region of the disc where gravitational effects are dominant (i.e. close to the black hole).

A slightly more complex situation appears during the 2002 I Zw 1 observation. The broad, ionised iron emission line previously discovered with *ASCA* (e.g. Leighly 1999) was de-

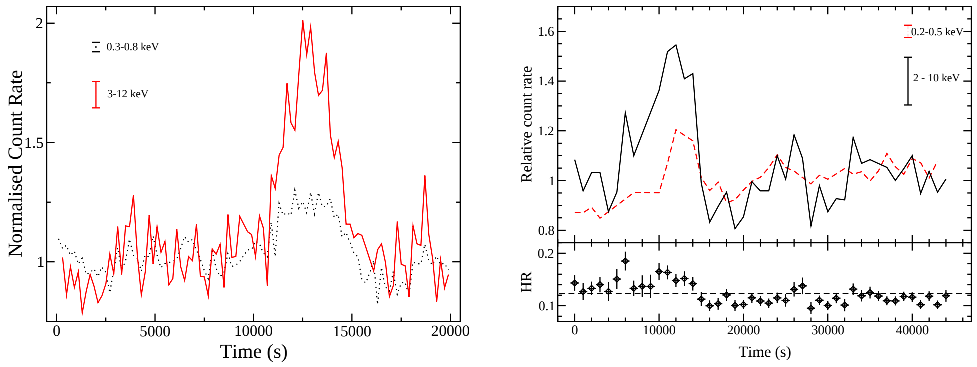

Fig. 1. High- and low-energy light curves normalised to the respective average high- and low-energy flux. Left: I Zw 1 light curves. The energy in the flare is clearly dominant in the higher energy band. Right: NAB 0205+024 light curves and hardness ratio (*HR*) showing that the flare is hard.

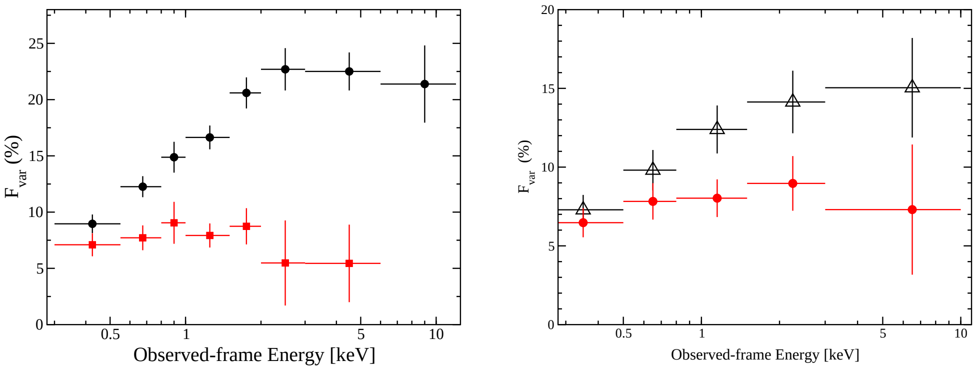

Fig. 2. The fractional variability amplitude spectrum calculated twice for each object: 1) for the entire observation (black marks) and 2) when the flaring period is neglected (red marks). I Zw 1 is shown on the left and NAB 0205+024 is shown on the right. The variability during the flare is consistent with a power-law that is varying in normalisation, but not shape. The diminishing of the variability toward lower energies is likely due to a second more constant and softer continuum component.

tected. In addition a second redder iron line was also seen (Fig 4, Gallo et al. 2004a). As the energy of this feature was consistent with 6.4 keV the authors identified it with neutral iron emitted from a distant putative torus.

However, a re-analysis of these data by Gallo et al. (2007a) provide a second interpretation for the origin of this line. Gallo et al. (2007a) found that the intensity of the redder line was well-correlated with the light curve of the continuum. On the other hand, the bluer line, arising from ionised iron, did not respond to the continuum variations (Fig. 5).

4. A possible picture of the corona in I Zw 1

The 2002 observation of I Zw 1 along with a second observation conducted in 2005 (Gallo et al. 2007a,b) suggest that the corona simultaneously exists in two phases. The first component is a hot, optically thin plasma that blankets several tens of gravitational radii of

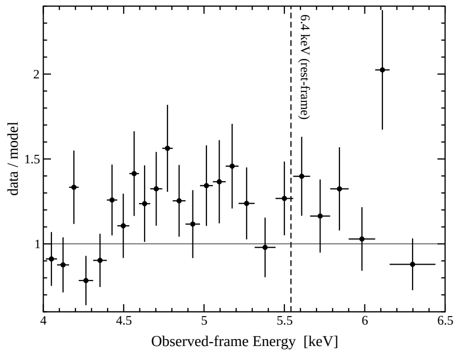

Fig. 3. Residuals from fitting the spectrum of NAB 0205+024 with a power-law continuum. Excess emission is observed redshifted from 6.4 keV.

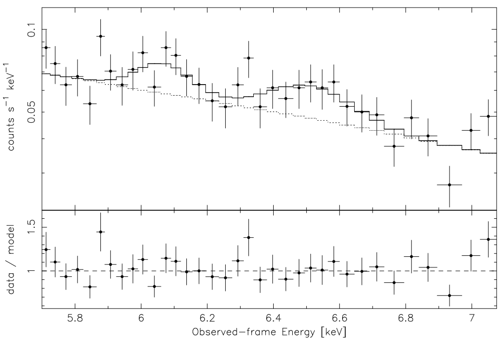

Fig. 4. A fit to the 2002 spectrum of I Zw 1 showing two broad Gaussian profiles. The broad, high-energy component was previously observed with *ASCA*. The redder line is transient as it was not seen in a follow-up observation in 2005.

the accretion disc and is responsible for the mean X-ray properties exhibited in I Zw 1. The second component is more compact and centrally located perhaps in a jet-like geometry. This component is responsible for the rapid events seen in I Zw 1 (e.g. flux flares and dips); illuminating the inner accretion disc, which produces redshifted reflection features in the spectra; and replenishing the more diffuse corona. This scenario to describe the corona in I Zw 1 (and likely NAB 0205+024) is similar to the aborted-jet model proposed for radio-quiet AGN (Ghisellini et al. 2004).

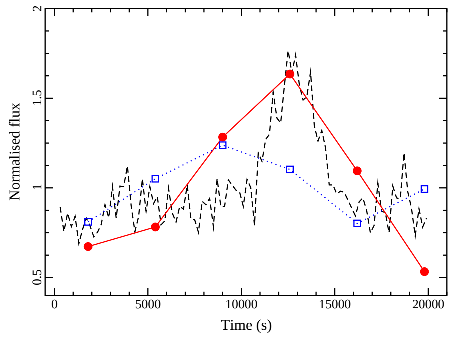

Fig. 5. Light curves of various spectral components in I Zw 1 normalised to their respective mean flux. The dashed curve is the high-energy continuum light curve shown in Fig. 1. The blue-dotted line is the light curve of the higher energy broad line seen in Fig. 4. The red-solid line is the normalised light curve of the low-energy emission line in Fig. 4. The intensity of the low-energy line tracks the continuum variations well indicating that the two components are linked.

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