RXTE Observation of the Seyfert 2 Galaxy NGC4507

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ABSTRACT. Preliminary results of the RXTE observation of the Seyfert 2 Galaxy NGC4507 are presented. The observed broadband [4-100 keV] spectrum is intrinsically hard ($\Gamma \approx 1.2$); an iron line is detected with a relatively high equivalent width ($EW \approx 400$ eV). The remaining calibration uncertainties are briefly discussed, as well as the scientific implications of our results.

1. The Bruno Rossi XTE Observatory

NGC4507 was observed by RXTE (Bruno Rossi X-ray Timing Explorer, Bradt, Rothschild and Swank 1993) from February 28 to March 10 1996. In this paper preliminary results of the data analysis are presented.

The FTOOLS 3.5.2 version was used to produce the following results. Data have been screened according to intervals of stable pointing (within $\sim 20$ arcseconds from the nominal one) and elevation angle higher than 10°.

Proportional Counter Array (PCA) background spectra estimate procedures are still in progress; available calibration files could account only for $\sim 70\%$ of the observed background counts. Thus, some of the relevant calibration files were provided by courtesy of PCA hardware group team for weak source calibration purposes. See http://lheawww.gsfc.nasa.gov/users/keith/ngc4507/ngc4507.html for a deeper discussion on the PCA background strategies and relevant outcomes. Data only from the first Xenon layer were collected and [4-60 keV] energy range adopted.

On the other hand, the Crab High Energy X-ray Timing Experiment (HEXTE) spectrum shows no deviation larger than 5% from a simple power law fit in the energy range [40-250 keV]. However, a clear $\approx 10\%$ deviation is visible in the residuals at lower energy than the Xe edge ($E \approx 35$ keV). Moreover the background subtracted NGC4507 HEXTE spectrum shows an anomalous increase of the counts above 100 keV. We decided therefore to restrict the HEXTE data analysis to the energy range [40-100 keV].

2. Spectral data analysis

NGC4507 is the hardest object in the Ginga sample (Smith and Done 1996) ($\Gamma = 1.39^{+0.70}_{-0.36}$); only very loose upper limits could be got on the reflected vs. direct component
Fig. 1. NGC4507 PCA+HEXTE spectrum (upper panel) and residuals (lower panel) when a simple power-law model is applied. HEXTE data points above 100 keV are also displayed to show the suspicious increase of the flux counts in the background subtracted spectrum, but were not used in the fits.

normalization ($R < 3.0$) and the presence of an iron line ($EW < 990$ eV). A more recent ASCA observation (Vignali et al. 1997) yielded best-fit values that were nearer to the typical values for Seyfert 2 spectra ($\Gamma = 1.75 \pm 0.14$, $EW = 190 \pm 40$ eV), although consistent with the Ginga outcomes within the statistical uncertainties. The [2-10 keV] flux is in the range $(1.6 - 2) \times 10^{-11}$ erg cm$^{-2}$ s$^{-1}$.

In Figure 2 the whole broadband PCA+HEXTE spectrum and the residuals when a simple absorbed power-law model is applied are shown. The spectrum is quite hard ($\Gamma = 1.2 \pm 0.2$) while the 2-10 keV flux is slightly lower than the previous measures $(F = 1.2 \times 10^{-11}$ photon cm$^{-2}$ s$^{-1}$ keV$^{-1}$). A clear emission-like feature is visible at energies $E \simeq 6.2$ keV, consistent with the K$\alpha$ fluorescence line from neutral matter after taking into account a residual $\sim 5\%$ systematic uncertainties in the gain relation. Such iron line is about twice that expected by emission from the line–of–sight absorbing material provided that the covering factor is a significant fraction of $4\pi$ (Awaki et al. 1991), (Ghisellini, Haardt and Matt 1994), and would then require a significant iron overabundance. An iron photoionization edge is also detected with an optical depth $\sim 0.4$ and energy consistent with the ionization state that can be derived from the line centroid energy.

The contemporary presence of hard spectrum, fluorescence emission line and photoionization edge is also suggestive of a Compton reprocessed continuum, even if the simple power law plus the line is formally a satisfactory fit to the data. The reflec-
tion XSPEC model PEXRAV has been used to test such an hypothesis. The results are:

\[ N_H = (34.1^{+0.8}_{-1.4}) \times 10^{22} \text{cm}^{-2}, \Gamma_{\text{dir}} = 1.95^{+0.09}_{-0.12}, N_{\text{refl}}/N_{\text{dir}} = 6.6^{+2.5}_{-1.8}, \text{ and } EW_{\text{F line}} = 370^{+40}_{-30}. \]

The spectral index of the intrinsic power-law turns out to be consistent with the one typically observed in Seyfert 1 X-ray spectra (Nandra and Pounds 1994); the Hydrogen equivalent column density \( (N_H \sim 3 \times 10^{23}) \) and iron line EW \( (\simeq 370 \text{ eV}) \) are consistent with the Ginga observation outcomes. However RXTE data requires a huge amount of reflection, the ratio between the reflected and direct components lying in the range \([4.8, 9.1]\). That could be a result of a delayed response of the reflecting matter to variation of the continuum (we actually detected the source at a smaller than usual flux level). The expected value of the iron line for such a value of \( R \) is about twice the observed best-fit value. \( R \) and EW are only marginally consistent with the model expectations.

Alternative models fails to fit the continuum shape. Neither a partial covering, nor a double absorber produce a satisfactory fit of the data but for the trivial values of the added parameters. No exponential cut-offs are required by the data. If the energy cut-off is fixed at \( E_{\text{cut-off}} = 70 \text{ keV} \) (as suggested by Bassani et al. 1995), the required spectral index is unphysically high (\( \Gamma = 0.8 \)) and the HEXTE data points remain systematically below the model.

3. Discussion

The RXTE spectrum of NGC4507 appears rather flat (\( \Gamma = 1.2 \)). Hard spectra have already been observed in other Compton–thin Seyfert 2’s [e.g. NGC5252, Cappi et al. 1996; NGC7172, Matt et al. 1997; see also Smith & Done 1996]; even if for each of these sources alternative explanations to an intrinsically flat spectrum cannot be ruled out, it is nevertheless rather embarrassing for unification models. For NGC4507, the only physically reasonable alternative accepted by the data is the presence of a huge \( (R = 6) \) Compton reflection component. The large value of \( R \) could be interpreted as delayed response of the reflection component to variations of the primary continuum, an explanation consistent by the fact that we have caught the source at a lower flux level than usual, and that the spectrum during a 1994 ASCA observation had a more typical spectral index (Vignali et al. 1997). The observed iron line is smaller than expected, suggesting an iron underabundance (it is worth noting that if this line would be interpreted as due to the line–of–sight absorbing matter, iron overabundance is required).

However, it is necessary to get rid of any problems concerning the instrumental calibration, and the background subtraction procedures (the latter particularly relevant for a weak sources like NGC4507) before any final astrophysical conclusion is drawn. The Figure 3 shows the broadband NGC4507 light curve for both the PCA and HEXTE detectors. Systematics \( \sim 30\% \) are still present. Such effects are likely to be mainly due to an incorrect background subtraction procedure and are currently still under investigation by RXTE team.

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Fig. 2. Broadband NGC4507 light curves in the PCA (upper panel) and HEXTE (lower panel) detectors

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