BeppoSAX Observations of the Seyfert 1 Galaxy NGC 3516

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We present the results of two observations of the bright Seyfert 1 galaxy NGC 3516, obtained with BeppoSAX in 1996 November and 1997 March. Useful signal is detected between 0.2 and 60 keV, allowing for the first time the simultaneous observation of all main spectral features. The source was brighter by a factor 2 at the second epoch of observation. Both spectra present a strong Fe Kα line, and a reflection hump at high energy. An absorption edge at 0.8 keV is visible in the later spectrum, but not in the earlier one, indicating that this feature is strongly variable.

1. INTRODUCTION

The bright Seyfert 1 galaxy NGC 3516 was noted in the ’80s for the detection in IUE spectra of a broad (∼2000 km s⁻¹) trough cutting into the C IV λ1549 emission line at ∼−500 km s⁻¹ with respect to the line peak ([1], and references therein). This feature, attributed to line-of-sight absorption within the source itself, had disappeared by 1993, and has not been detected again. Similar features were observed in the optical Balmer lines during the LAG monitoring campaign of 1990 ([2]).

More recent X-ray data from Ginga, ROSAT, and ASCA have shown that NGC 3516 has a warm absorber (O VII/O VIII and Fe edges have been detected), as reported by [3]. The latter show that the properties of the O VII/O VIII edges are compatible with NH ∼ 7 × 10²¹ cm⁻² and ionization factor U ∼ 8–13. The warm absorber is also variable.

In [3] it is suggested that the absorption features in the UV/optical and X-ray bands are all due to the same gas component as it evolves in time: an outflow and expansion compatible with the kinematic characteristics of the UV/optical absorption would produce the increase in ionization required to explain the disappearance of the UV/optical absorption itself, while the X-ray warm absorber would be still visible. The prediction is that the warm absorber should also disappear on a time-scale of a few years as the ionization of the gas increases further.

We have therefore observed NGC 3516 with all narrow-field instruments of BeppoSAX at 2 epochs (1996 November and 1997 March, 50 ksec per observation) in order to test this prediction. In addition we have HST spectra from 5 epochs of 1996/1997, taken to check whether the broad absorption should reappear in the UV band.

Further aims of the project are (a) to use the wide spectral range of BeppoSAX to study the broad-band continuum characteristics such as the reflection component at high energy, and (b) to study the Fe Kα line first detected by ASCA [6].

This paper presents preliminary results from the BeppoSAX observations.

2. BROAD BAND CHARACTERISTICS

Within the BeppoSAX range, NGC 3516 has useful continuum emission from 0.2 to 60 keV. The spectra of both epochs are partly shown in Fig.1, each compared to a best-fit power-law. The
photon indices obtained for this simple model are in agreement with those yielded by the ASCA data in [4] and by part of the Ginga data in [3]. The spectra display features characteristic of Seyfert 1 galaxies in this band: the Fe Kα line is clearly visible, and a reflection hump is present between 13 and 40–50 keV. To our knowledge, this is the first detection of a reflection hump in NGC 3516.

At the second epoch the source was stronger by a factor 2 with respect to the first observation. Weak variability (∼20%) was detected on timescales of 10^4 s.

3. THE FE Kα LINE AND EDGE

The Fe Kα emission line is well visible in both spectra. Although there is an indication that the profile is red-asymmetric, there are not sufficient constraints to discriminate strongly between a broad accretion-disk profile, and a narrow emission line + Fe edge model (both shown in Fig.2, fitted to the 1996 spectrum). The results of the fits of both models to our spectra are listed in Table 1. The parameters of either model do not differ significantly at the two epochs of observation. The narrow-line + edge model gives a slightly more significant fit ($\chi^2 = 154.4$ on 160 d.o.f. against $\chi^2 = 163.1$ on 161 d.o.f. in the 1996 spectrum). In view of this, and because the EW and width in the broad line model seem unreasonably large, we believe that the narrow-line model is more acceptable. While our results for the narrow line and edge energies agree with those from the warm absorber fits of [3] to Ginga data, our equivalent width values are significantly lower. The present results for the iron line EW are also in agreement with the ASCA results [4].

A detailed comparison is not straightforward, as in [4] the iron line has been modelled with a broad plus a narrow component. The lower resolution of BeppoSAX does not constrain this model sufficiently.

4. THE WARM ABSORBER

One of the most surprising results of these observations concerns the absorption edge at ∼0.8 keV. While it is clearly visible in the second, stronger spectrum, there is no evidence of its presence in the first one (Fig.3). There is thus evidence for a complex ionization structure, which almost certainly depends on the continuum flux, as well as possibly on time. While the XUV model
Figure 2. The MECS spectrum of 1996 November, fitted with a power-law and two different models for the Fe Kα profile: a broad profile (left), and a narrow line + Fe edge (right).

Figure 3. The LECS spectra of 1996 November (left) and 1997 March (right) divided by a power-law. Note that no absorption edge is visible at $\sim 0.8$ keV in the first spectrum, while it is clearly present in the later observation.
Table 1
Results of fits to Fe line and edge

|            | Broad line model | Narrow line + edge model |
|------------|------------------|--------------------------|
|            | E (keV)          | σ (keV)                  | E (keV) | EW (eV)  | Line                          | Edge                        |
|            |                  |                          |         |          | E (keV) | EW (eV) | E (keV) | τ        |
| 1996 Nov.  | 6.21 ± 0.20      | 0.73^{+0.29}_{-0.23}    | 500^{+241}_{-157} |        |
| 1997 Mar.  | 6.05^{+0.30}_{-0.45} | 0.97^{+0.38}_{-0.35}    | 464^{+329}_{-175} |        |
| 1996 Nov.  | 6.41 ± 0.09      | 142 ± 46                 | 7.82^{+0.25}_{-0.22} | 0.30^{+0.12}_{-0.10} |
| 1997 Mar.  | 6.45 ± 0.10      | 86 ± 35                  | 7.75 ± 0.16     | 0.28 ± 0.08 |

proposed in [3] cannot be confirmed or disproved at this stage, it will have to take into account the effects of flux variations on time-scales of a few months.

A preliminary fit to the absorption in the 1997 spectrum yields \( \tau_{\text{O VII}} = 1.27^{+0.53}_{-0.46} \) and \( \tau_{\text{O VIII}} < 0.68 \), which are in formal agreement with most of the fits to ROSAT data performed by [3].

5. CONCLUSIONS

We have presented preliminary results from two BeppoSAX observations of NGC 3516. Useful emission was detected up to 60 keV, which gives unprecedented wavelength coverage of the X-ray spectrum of this bright Seyfert 1 galaxy. Several features typical of Seyferts — Fe Kα line, reflection hump at high energies, and a warm absorber edge at \( \sim 0.8 \) keV in the later spectrum — are visible and will be the object of further study. Of particular note is the strong variation of the absorption edge, which was not detected in the first, weaker spectrum. This will require that current XUV absorber models take into account the effects of flux variations on time-scales shorter than those required for the dynamical evolution of the absorbing gas. In any case, the fact that the Fe edge is visible in both spectra while the O VII/O VIII edge is not implies that they are not produced by the same gas.

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