ROSAT and ASCA Observations of the Seyfert galaxy 1H0419-577, Identified with LB 1727

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ABSTRACT

We discuss the properties of the Seyfert 1.5 galaxy LB 1727 based upon the analysis of two *ASCA* observations, a two-month *Rosat* monitoring campaign, and optical data. The target is identified with the HEAO-A1 source 1H0419-577, so it has been observed by *ASCA* and *ROSAT* in order to obtain better X-ray variability and spectra data. Only modest (20%) variability is observed within or between *ASCA* and *BeppoSAX* observations in the $\sim 2-10$ keV band. However, the soft X-ray flux increased by a factor of 3 over a period of 2 months, while it was monitored daily by the *ROSAT* HRI instrument. The hard X-ray continuum can be parameterized as a power-law of slope $\Gamma \sim 1.5 - 1.6$ across 0.7 - 11 keV in the rest-frame. We also report the first detection of an iron Kα line in this source, consistent with emission from neutral material. The X-ray spectrum steepens sharply below 0.7 keV yielding a power-law of slope $\Gamma \sim 3.2$. There is no evidence for absorption by neutral material, intrinsic to the nucleus. If the nucleus is unattenuated, then the break energy between the soft-excess and hard component is 0.7 ± 0.08 keV. An ionized absorber may produce some turn-up in the spectrum at low energies, but a steepening of the underlying continuum is also required to explain the simultaneous *ASCA* and HRI data. We cannot rule out the possibility that a significant column of ionized material exists in the line-of-sight, if that is true, then the continuum break-energy can only be constrained to lie within the $\sim 0.1 - -0.7$ keV band.

Subject headings: galaxies:active – galaxies:nuclei – X-rays: galaxies

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1. Introduction

It has long been suggested that the putative accretion disk around the black hole of an AGN will emit copious amounts of UV and soft X-ray radiation. Thus the spectral energy distribution (SED) of an AGN across this range should provide crucial information about the accretion disk, reprocessing mechanisms close to the active nucleus and physical conditions in the circumnuclear material.

Determination of the X-ray to UV (XUV) continuum in AGN has been extremely difficult because of the severe attenuation of photons of these energies by even small amounts of Galactic material along the line-of-sight to the AGN. However, some indication of the strength of the unseen continuum has been inferred from the strengths of emission lines such as HeIIλ1640 (e.g. Mathews & Ferland 1987). In fact, a longstanding suggestion has been that there is a so-called "blue-bump" of continuum emission, peaking in the unseen XUV regime (Shields 1978, Malkan & Sargent 1982). The advent of new and sensitive satellites has started to narrow the "unobservable" bandpass. In fact the *EUVE* satellite detected many Seyfert galaxies (Marshall, Carone and Fruscione 1995). Furthermore, rapid variability in the EUVE flux of those sources indicated the observed radiation to be originating in the inner nucleus.

Recent work by Zheng et al. (1997, 1995) has suggested the form of the unseen XUV spectrum is $f_v \propto v^{-2}$ between the Lyman limit (at 912 Å) and $\sim$ 0.5 keV. Laor et al. (1997) combine this with a mean soft X-ray spectrum, based upon *ROSAT* observations of quasars, to dispute the existence of a large XUV bump. Korista, Ferland and Baldwin (1997) have discussed the problem that extrapolating the known soft X-ray spectrum of AGN, there appear to be too few 54.4 eV photons to account for the strength of the observed HeII lines. They consider the possibility that the broad-line clouds see a harder continuum than the observer does, or that the XUV spectrum has a double-peaked shape. Clearly, a careful determination of the detailed shape of the XUV continuum would provide a large step forward in our understanding of many fundamental processes in AGN. While numerous observations of AGN have been performed in the past, little is known about the spectral shape below $\sim$ 0.6keV. Previous soft X-ray observations have yielded narrow-band spectra with low energy resolution (e.g. the *ROSAT* PSPC, *Einstein* IPC, *EXOSAT* CMA). *ASCA* has only yielded reliable spectra above 0.6 keV (although data may eventually be available down to 0.4 keV, with improved calibration). Disagreements between *ASCA* and *ROSAT* data, in the overlap bandpass (0.6-2 keV) have led to some controversy as to whether the underlying continua of emission-line AGN actually do steepen to softer X-ray energies. Some sources definitely show a significant spectral softening below $\sim$ 1 keV, however, in most cases, the origin of this effect is ambiguous. It is now known that the majority of Seyfert 1 galaxies suffer attenuation by ionized material, obscuring the nucleus (Reynolds 1997; George et al. 1998). Ionized material can have a reduced opacity in the soft X-ray band, and produce a spectrum which steepens to soft energies. In most cases studied to date, X-ray spectra do not allow us to distinguish between a single continuum component attenuated by ionized material, and steepening of the underlying emission spectrum. Clearly, the best sources for attempting to unambiguously distinguish between the aforementioned pictures should be bright in the soft X-ray regime, and have minimal absorption. LB 1727 is one of the brightest Seyfert galaxies detected by *EUVE* (Marshall, Carone, and Fruscione 1995), yet this has a very flat spectrum in the hard X-ray regime (Guainaziiet al. 1998). This suggest the source might show a clear steepening of spectral slope in the soft X-ray regime; this, combined with the low Galactic column along the line-of-sight, make LB 1727 a good target to search for the soft X-ray tail of an XUV bump.

High resolution spectra in the soft X-ray band have been obtained using EUVE for only a few targets, notably Mrk 478 and NGC 5548. Marshall et al. (1996) showed that the EUV flux from Mrk 478 was highly variable and could be attributed the high energy portion of an accretion disk spectrum because no emission lines were observed. Similarly, Marshall et al. (1997) showed that the soft X-ray spectrum of NGC 5548 showed no emission lines, was variable on a time scales of days, and that variations were correlated with UV variations, again consistent with emission from the inner regions of an accretion disk.

2. The Seyfert galaxy LB 1727

LB 1727 is a Seyfert galaxy first noted as a very blue object by Luyten & Miller (1956) during their search for faint blue stars. The object was discovered in the X-ray sky-survey performed by the HEAO-1/A1 experiment, covering the 0.25 – 25 keV band, during late 1977 to early 1978 (Wood et al. 1984). At that time, the 2–10 keV flux was $\sim 2 \times 10^{-11}$erg cm^{-2}s^{-1} in the rest-frame. The HEAO-1 detection yielded the alternative (and commonly used) designation 1H 0419-577. The HEAO-1/A1 survey was followed by a program of optical identifications, which found the bright X-ray source 1H 0419-577 to be a most likely identified with a Seyfert galaxy (Brissenden et al. 1987). The source was later detected in the Einstein slew survey (Elvis et al. 1992) and by *ROSAT* with both the Position Sensitive Proportional Counter (PSPC) and in the Extreme Ultraviolet Explorer (*EUVE*) all sky survey (Marshall, Carone, and Fruscione 1995). Thomas et al. (1998) confirmed that LB 1727 was a bright X-ray source and a Seyfert 1.5 galaxy, with a redshift measurements of z=0.107 (Brissenden et al. 1987) and z=0.104 (Grupe 1996; Thomas et al. 1998). We adopt z=0.107 in our analysis of the X-ray data, and we assume

$H_0 = 50$, $q_0 = 0.5$. This source was the second brightest AGN detected in the EUVE all sky survey, (Marshall, Carone and Fruscione). These observations have lead to several alternative designations including: 1H 0419-577, 1 ES 0425-57.2, EUVE J0425-57.2, and 2RE J042537-571348.

Guainazzi et al. (1998) report on a *BeppoSAX* observation of LB 1727 performed 1996 September 30. The exposure time was $\sim$ 23ks with the Medium Energy Concentrator Spectrometer (MECS) which has an effective bandpass $\sim 1.8 - 10$ keV. Unfortunately the Low Energy Concentrator Spectrometer (LECS), which covers 0.1 – 10 keV band, was switched off during the observation because of technical problems. The source was also marginally detected in the *BeppoSAX* Phoswitch Detector System (PDS), providing some constraint on the flux up to 36 keV. The *BeppoSAX* data revealed a flat spectrum in the 1–10 keV (observed) band, with photon index $\Gamma \sim 1.6$ and no evidence for line emission from the K-shell of iron. Guainazzi et al. (1998) also reported an index $\Gamma \sim 2.7$ from PSPC data covering the 0.1–2 keV band, indicating marked spectral variability and/or a sharp steepening of the spectrum below $\sim$ 2 keV.

Here we present the results of new X-ray observations of LB 1727, along with several optical spectra. In §2 we present analysis of optical spectra from 1988 and 1993. In §3 we detail the timing and spectral results from two *ASCA* observations from July and August 1996. In §4 we show the results of a two-month monitoring campaign using the *ROSAT* HRI. We attempt to reconcile the apparent discrepancy between the X-ray and optical attenuation in §5, and in §6 we discuss the overall spectral energy distribution (SED) of the source. In §7 we discuss all of these results along with implications regarding the presence of a continuum component peaking in the X-ray to ultraviolet (XUV) regime, i.e. the so-called "XUV bump".

3. The Optical Spectra

LB 1727 has been observed several times, in attempts to identify sources from hard and soft X-ray surveys (Brissenden et al. 1987; Grupe 1996; Thomas et al. 1998, Guainazzi et al. 1998). The optical spectra are shown in Fig. 1, and were accumulated during 1988 Feb 17 and 22, on the 3.9m Anglo-Australian Telescope (AAT) and the Australian National University(?) (ANU) 2.3m telescope, respectively. Both observations utilized double-spectrographs *more detail- Ron* . An optical spectrum was also accumulated 1993 Sept 14 with the MPI/ESO 2.2m telescope at La Silla, using the Faint Object Spectrograph and Camera. The ESO 2.2m observations used grisms yielding 5 Å FWHM resolution over the $6600 - 7820$Å and 4640-5950 bandpasses, plus 22Å FWHM over $3400 - 9200$Å ; with exposure times of 15, 20 and 5 minutes respectively. The detailed reduction method for the ESO 2.2m data is described in Grupe (1996) and for the ANU and AAT data it is described in Brissenden et al. (1987).

3.1. The AAT data

Fits yielded FWHM [OIII]/ = 580km s−1, FWHM Hβ_{narrow} = 1225km s−1 and Hβ_{broad} = 4200km s−1.

3.2. The ANU data

For these data the [OIII] line was fit with a gaussian profile, yielding FWHM= 790km s−1. A template was made of this line profile, and this was scaled to the flux of the narrow component of Hβ (with a ratio [OIII]/H$\beta \sim 1/10$). The scaled template was shifted to the energy of the narrow component of the Hβ line and then subtracted from the total Hβ profile. The remaining Hβ profile was then dominated by the broad component of Hβ, which yielded a width measurement 2950km s−1. This left a residual narrow component of Hβ with FWHM=1080km s−1. (It was not possible to satisfactorily apply this method to the AAT data).

3.3. The ESO 2.2m data

These data yielded FWHM [OIII] = 450km s−1 and Hβ_{narrow} = 700km s−1, Hβ_{broad} = 2900km s−1 (corrected for instrumental resolution).

The blue optical continuum, with $\alpha_{opt} = 0.0$ (Grupe et al. 1998b), combined with the presence of such a strong and steep soft X-ray component ($\alpha_X = 2.2$ during the RASS between 0.2-2.0 keV) might lead us to expect to see an optical spectrum reminiscent of a NLS1 galaxy. However, it is not. First of all the width of the broad Hβ component is far from fitting into the NLS1 defintition. Second the [OIII]/Hβ ratio (~ 1.5) is fairly strong and thrid there is nearly no FeII emission found in the optical spectrum. Grupe et al. (1998b) report an equivalent width for the FeII emission between 4250 - 5880 Å of 30Å and a FeII/Hβ ratio of 0.4. These FeII measurements have to be taken as upper limits.

To determine the Balmer decrement we used the total fluxes in the H*alpha* and Hβ lines. Unfortunately it is not possible to estimate the broad and narrow decrements separately in these data. because it is difficult to deconvolve the components of Hα. By using the [OIII] template (see section 2.2) we are able to subtract the narrow line emission from the Hβ line, but this is not possible with the Hα line. Unfortunately, Hα is also contamined by the [NII] 6548Å and 6584Å. To subtract the contributions of these lines we subtracted 35% of the [OIII]5007 line flux from the total Hα line flux (The [NII]/[OIII] ratio was suggested by Ferland & Osterbrock, 1986). Subtracting this contaminating flux allows us to make an estimate of the mean Balmer decrement, Hα/Hβ = 4.2. This decrement corresponds to an optical extinction $A_V = 1.21$ and an X-ray absorption $N_H \sim 1.8 \times 10^{21}$cm^{-2}, assuming material with a Galactic dust-to-gas ratio. The broad component of the line is clearly suppressed (compared to a Seyfert 1 galaxy) and the obscuration to the broad-line-region is likely somewhat higher than this mean value. We return to this point later.

4. ASCA Observations and Data Reduction

ASCA (Makishima et al. 1996) has two solid-state imaging spectrometers (SISs; Burke et al. 1994) and two gas imaging spectrometers (GISs; Ohashi et al. 1996) sensitive across the $\sim$ 0.4 – 10 keV and $\sim$0.8 – 10 keV bandpasses, respectively. LB 1727 was observed by *ASCA* 1996 July 22-23 and August 10-11. The data were reduced in the same way as the Seyfert galaxies presented in Nandra et al. 1997a (N97a) and Turner et al. 1997. For details of the data reduction method see N97a. For the July observation, data screening yielded effective exposure times of $\sim$ 24 ks in all four instruments. For the August observation the exposure times were $\sim$ 23 ks in SIS and $\sim$ 26 ks in the GIS instruments.

4.1. Time Variability

The fluxes in the 0.5 – 2 keV rest-frame (0.45 – 1.81 keV observed-frame) were 4.8 and 5.5×10^{-12}erg cm^{-2}s^{-1} during the July and August epochs observed by *ASCA*.

The 2 – 10 keV rest-frame flux (1.81 – 9.03 keV observed-frame) was $0.94 and 1.1 \times 10^{-11}$erg cm^{-2}s^{-1} during the 1996 July and August observations, respectively. This is evident as a small flux change in the hard-band light curves (Fig. 2). These flux states are consistent with that observed by *BeppoSAX* a month later, 1996 September 30 (Guainazzi et al. 1998). This flux infers a luminosity of L(2-10)4.8 – 5.6×10^{44}erg s^{-1} (assuming $H_0 = 50$, $q_0 = 0.5$). Thus the source has faded by a factor of 2, compared to the flux-state at which it was observed by HEAO-1/A1 (Wood et al. 1984).

We tested the light curves for variability using the χ^2 statistic, and the source showed no significant variability in either band when sampled in 256 s or 5760 s bins. Fig. 2 shows the light curves constructed in the 0.5 – 2 keV and 2 – 10 keV band and sampled on 5760 s. There is obviously a evidence for a $\sim$ 60% increase in soft flux and a $\sim$ 20% increase in the 2 – 10 keV flux between July and August 1996. Integration using 1024 s bins revealed evidence for flickering at the 10 – 30% level (at > 90% confidence) in both bands during the July observation, but no significant variability during the August observation.

4.2. The X-ray Spectra

ASCA data cover the 0.4-10 keV observed band. However, SIS data below an energy of 0.66 keV, rest-frame, (0.6 keV observed-frame), were excluded from the spectral analysis as it is commonly accepted that there are uncertainties associated with the *ASCA* calibration in that band. However, we make use of the fact that the calibration uncertainty is considered to be $\lesssim$ 20%, and usually results ion a systematic deficit of counts. If data in the 0.40-0.60 keV band lie above the extrapolation of our model, then the source spectrum most likely does steepen in that band. Later we take the approach of indicating where these data lie, although we never use them in a fit.

4.2.1. 1996 July

Data in the 4.5-6.8 keV range (5-7.5 keV in the rest-frame) were first excluded, to temporarily remove the channels in which iron Kα emission would occur if present in this source. This exclusion allows us to parameterize the continuum shape more easily.

The spectrum was fit across the 1.81–9.03 keV in the observed band (2-10 keV rest-frame) using a power-law attenuated by a column of neutral material. Preliminary fits showed no evidence for absorption, so the column was fixed at the Galactic value, $N_H = 2.25 \times 10^{20}\mathrm{cm}^{-2}$ subsequently. The 1996 July data yielded a photon index Γ_{rest}(2-10)= 1.48$\pm$0.07 and χ^2 = 280 for 319 degrees of freedom (*dof*). Fitting the full *ASCA* band (0.6-10 keV observed-frame, 0.66-11.1 keV rest-frame but still excluding the iron Kα band) yields Γ_{rest}(0.66-11.07)= 1.45$\pm$0.03 for χ^2 = 488/533 *dof*. Thus there is no evidence for significant spectral curvature down to a rest-energy of $\sim$ 0.7 keV.

We then included the 5.0 – 7.5 keV data, Fig. 3 shows where these data lie, compared to the power-law model. There is some evidence for emission from the iron K-shell. Addition of a Gaussian emission component to the model provides a reduction in χ^2 of 11, for three fewer *dof* (compared to a re-fit including the 5-7.5 keV data but no gaussian model), suggesting the presence of an emission line, at the 95% confidence level. The line has $E = 5.95^{+0.55}_{-0.40}$ keV, $\sigma = 0.26^{+0.74p}_{-0.26p}$ keV, $I = 2.36^{+2.87}_{-2.01} \times 10^{-5}$photons cm^{-2}s^{-1}; yielding an equivalent width $EW = 172^{+208}_{-147}$ eV. This is the first detection of iron Kα emission from this source. Unfortunately there were too few photons in the line to merit more detailed modeling of the profile.

Fig. 3 also shows the 0.4–0.6 keV data overlaid on the data/model plot (based upon the best-fit model). Those data lie significantly above the extrapolation of the model, and indicate a significant steepening of the spectrum below a rest-energy $\sim$ 0.7 keV, an indication of the presence of a spectral break.

4.2.2. 1996 August

We treated these data in the same way as the July observation. Finding Γ_{rest}(2-10)= 1.61$\pm$0.06, χ^2 = 378/389 *dof*. The full band gave Γ_{rest}(0.66-11.07)= 1.68$\pm$0.03, χ^2 = 641/644 *dof*. We included the 5.0-7.5 keV (rest-frame) data, and Fig. 3 shows the ratio plot compared to the power-law model. Again there is some suggestion of emission from the K-shell of iron, a gaussian emission component was added to the model and the data were re-fit.

At this epoch the addition of an emission line yields an improvement $\Delta\chi^2 = 35$ for three fewer *dof*, significant at > 99% confidence. The line has a rest-energy $E = 6.41^{+0.68}_{-0.66}$ keV, with width $\sigma = 1.0^{+0p}_{-0.35}$, normalization $I = 9.56^{+3.51}_{-5.42} \times 10^{-5}$ photons cm^{-2} s^{-1} and $EW = 698^{+332}_{-334}$ eV. This fit yielded χ^2 = 800/859 *dof* and the data suggest the line intensity has increased since the July data, however, this is a tentative result, given the absolute weakness of the line.

The 0.4 – 0.6 keV data were overlaid on the data/model plot and once again these data lie significantly above the extrapolation of the model (Fig. 3). These data support the suggested steepening of the spectrum below 0.7 keV. However, the *ASCA* data alone do not allow us to distinguish between the presence of a complex absorber, or of a separate continuum component.

5. The ROSAT Observations

5.1. PSPC

The *ROSAT* PSPC data are of interest with respect to the aforementioned spectral break. LB 1727 was observed by the *ROSAT* PSPC on 1992 April 07. The data were corrected for time dependant effects using the ftool PCPICOR, and source and background spectra were extracted. The source flux was F_{rest}(0.5-2 keV)= 1.9×10^{-11}erg cm^{-2}s^{-1} and increased by $\sim$ 5% over the 40 ks separating the observation intervals comprising this dataset. The spectrum was fit with a simple power-law, attenuated by an neutral absorber, which was unconstrained. It was impossible to achieve an acceptable fit using this model. The data/model ratio plot is shown in Fig. 4, demonstrating a sharp break in the spectrum at $\sim$ 0.7 keV, in agreement with the break-energy inferred from the *ASCA* data. Fits to the PSPC data are tabulated in Guainazzi et al. (1998), and we find similar results, however we note our own fit results briefly, for ease of discussion and comparison with the *ASCA* data which follows.

The PSPC data indicate a power-law of photon index $\Gamma = 2.61 \pm 0.15$ dominates the PSPC data above an observed energy of 0.7 keV, steepening to $\Gamma = 3.72^{+1.18}_{-0.33}$ below 0.7 keV with fitted column density $2.93^{+0.70}_{-0.22} \times 10^{20}$cm^{-2}, slightly higher than the Galactic value, giving $\chi^2 = 35/15$ *dof*. The soft index is inferred to be $\Gamma = 3.24 \pm 0.08$ if the neutral column density is fixed at the Galactic value, but the fit is worse with $\chi^2 = 51/16$ *dof*. Much of the contribution to χ^2 arises in the 0.3-0.4 keV regime, but as this is where the gradient of the instrument effective area is steepest, we do not attempt to fit the complexity in that regime. An alternative model is that of a power-law with an edge which yields $\chi^2 = 24/14$ *dof*, $\Gamma = 3.02^{+0.14}_{-0.11}$ and a rest-energy $E = 0.58 \pm 0.05$ keV for an edge of depth $\tau = 0.96^{+0.34}_{-0.32}$ and $N_H = 2.50^{+0.40}_{-0.34} \times 10^{20}$cm^{-2}. In the aforementioned fits, the PSPC slope is inconsistent with the *ASCA* spectral index in the overlapping bandpass (which is effectively 0.6-2.0 keV). This inconsistency is either attributable to spectral variability of the source, or to a greater degree of inconsistency in the cross-calibration between the PSPC and *ASCA* than previously thought. An astrophysical explanation might be that the soft spectral component was relatively strong during the PSPC epoch, and dominated the spectrum up to a higher energy than during the *ASCA* observation. In fact, as we will demonstrate, the source was at a historically high flux state during this PSPC observation. The luminosity in the soft component is $\sim 10^{45}$erg s^{-1} in the PSPC bandpass, so this emission cannot be attributed to starburst emission in the host galaxy, and thus is most likely associated with the central engine, and could be expected to vary.

The relative superiority of the fit featuring an absorption edge lead us to model the data using a power-law absorbed by a column of ionized material. We utilized the ION models as for the *ASCA* data (George et al. 1998). We found a best-fit ($\chi^2 = 41/16\ dof$) for a power-law of index $\Gamma = 3.30^{+0.15}_{-0.20}$ covered by a column $3.63\pm1.00 \times 10^{21}\mathrm{cm}^{-2}$ of ionized material, $U_X = 5.8^{+6.0}_{-2.1} \times 10^{-3}$ (with an additional column of neutral material, fixed at the galactic value, covering the source). Thus it is evident that even allowing the modification of spectral shape by a column of ionized material, the underlying spectral slope is still inferred to be much steeper than that in the 1-10 keV band. Fitting the *ASCA* and *ROSAT* data together, with the relative normalizations of the two datasets allowed to be free, we again found it necessary to include a steepening of the underlying continuum to soft energies, even if an ionized absorber is included in the model. However, the lack of simultaneity of the PSPC and *ASCA* observations leaves a great deal of uncertainty as to how the combined PSPC/*ASCA* fit should be interpreted. Fortunately, there were some HRI data taken simultaneous with an *ASCA* observation.

5.2. The HRI data

LB 1727 was monitored daily by the HRI, covering a two month period from 1996 June 30 to 1996 September 01, including a long integration simultaneous with the *ASCA* observation in July. The aim of the observations was to study the variability behaviour of this source on a number of timescales, particularly the days-to-weeks timescales which have not been extensively studied in Seyferts as a class.

The HRI data were co-added and an image was produced (Fig. 5). The image shows that the only X-ray sources close to LB 1727 are relatively faint, and unlikely to cause any significant contamination of the *ASCA* spectrum. One of the sources was bright enough for a PSPC spectrum to be extracted, which was found to be very steep, further confirming this would not contaminate the *ASCA* data.

A radial profile was extracted, and compared to the point-spread-function (psf) of the instrument. A small excess is observed over the psf, between 12-18″ from the centroid position. However, such an excess is commonly seen in calibration (point) sources. This is thought to be a deficiency in the psf model, and so we conclude there is no significant evidence for extended X-ray emission associated with LB 1727 in these data.

Fig. 6 shows a light curve based upon the *ROSAT* monitoring campaign. The background level was insignificant compared to the source flux and background has not been subtracted from the source light curve. However, the background light curve is shown on the same plot (rescaled to the level appropriate to the source extraction cell). It is difficult to make a sensitive search for rapid variability because the HRI background rate varies by large amplitudes (factors of several) across the observation, and small errors in subtraction of this background light curve will introduce spurious effects into the source light curve. We found no evidence for rapid variability which was not attributable to variations in the background rate. However, significant variations in flux were observed on timescales of ~ 40 ksec. Moreover, the source flux increased by a factor of ~ 3 across the 2 month period covered by the HRI observations. One of the strongest increases being a factor of two change in 5 days, in the middle of the campaign. The amplitudes and timescales of variability seen here are similar to those observed in some other Seyfert 1 galaxies, like Mkn 335 (Turner & Pounds 1988), the timescales are longer and the amplitude of variability is small compared to behaviour observed in some NLS1 galaxies such as Mkn 478 (Marshall et al. 1996).

6. Models to reconcile the X-ray and optical absorption

Although the *ASCA* data do not indicate the presence of X-ray absorption, the optical data did indicate the presence of some attenuation, affecting the $H\alpha/H\beta$ ratio. Thus it is interesting to examine constraints on the amount of absorbing material which could be present.

First, we find the *ASCA* data are inconsistent (at $> 99\%$ confidence) with a screen of neutral gas of column $2 \times 10^{21}\mathrm{cm}^{-2}$ fully covering the source; i.e. the column implied from measurement of Balmer decrement. The data are inconsistent with such a column, even if the covering fraction is allowed to be as small as 10%. The soft X-ray data are even more clearly inconsistent with the presence of such a column, in fact PSPC data indicate an upper limit (90% confidence) $N_H < 4 \times 10^{20}\mathrm{cm}^{-2}$ (see the next section). However, if the nucleus is enshrouded in ionized, dusty material, then the X-ray data could be unattenuated while the optical line ratios are affected. Thus we tried fitting warm-absorber models to the *ASCA* data.

We fit both the July and August data with models utilizing the ION model of Netzer (1993) (also see George et al. 1998 for a conversions between the various ionization parameters in common use, and for the warm-absorber fits to Seyfert 1 galaxies).

Taking the July data, the best-fitting column was $N_H^* = 7.6^{+34.6}_{-7.3} \times 10^{21}\mathrm{cm}^{-2}$ with $U_X \sim 2.0^{+8p}_{-1.8p}$. The August data yielded $N_H^* = 1.4^{+3.8}_{-1.37} \times 10^{22}\mathrm{cm}^{-2}$ with $U_X \sim 3.3^{+6.7}_{-2.71}$. Thus the existence of large amounts of highly-ionized, dusty gas could bring the X-ray and optical data into consistency.

The question then becomes, could the presence of ionized gas be the sole cause of the observed steepening of the spectrum below 0.7 keV. As noted above, fortunately, we have HRI data simultaneous with the *ASCA* spectrum accumulated during July. We fit the simultaneous HRI and *ASCA* data together, allowing a column of ionized material, as before. The HRI data lie significantly above the extrapolation of any of the reasonable models describing the *ASCA* data (Fig. 7). Although the HRI data provide just a single point, it was not possible to find an acceptable fit using a single power-law and an ionized absorber when this point was included. We take this result to mean that the emission spectrum of LB 1727 must steepen at or below 0.7 keV. If the source does not actually contain ionized gas, then the break-point is clearly 0.7 keV, if the source has a steepening spectrum and also is attenuated by ionized gas, then the break of the emission spectrum may be below of 0.7 keV, and what we see in the observed spectrum is a combination of the two effects.

This requirement for a steppening of the soft X-ray continuum, combined with the evidence for a very blue continuum in the optical regime indicates that a spectral component exists which peaks between these two extremes, the so-called XUV bump.

7. The UV to X-ray Spectrum

A spectral-energy-distribution was constructed for LB 1727. The absorption-corrected *ASCA*, *ROSAT*, *EUVE* (Fuscione, A. 1994) and infra-red data (Grupe 1996) are plotted in Fig. 8. *ASCA* and PSPC data are represented by the best-fitting model lines, to avoid cluttering the plot. Fig. 8 shows the best-fitting model to the 1996 August data from *ASCA*, extrapolated down to 0.1 keV, with (dotted-line) and without (solid-line) a warm absorber. The model for the 1992 PSPC data (crossed-line) is also shown, along with a flux point from the *ROSAT* sky-survey (filled box). This plot shows that the soft flux varies by an order of magnitude, comparing the PSPC survey and pointed observations, and the *EUVE* data (which represents the average flux based upon data from 1992 July through 1993 July). As noted above, the discrepancy between the soft X-ray data and the extrapolation of the *ASCA* model can be due to a combination of effects, i.e. flux and/or spectral variability and a change in the underlying continuum below 0.7 keV.

We examined the shape of the spectral-energy-distribution, by looking at the multiwaveband data compiled by Grupe (1996). Those data show infra-red and optical fluxes compared to the X-ray flux taken from the PSPC data. LB 1727 shows a normal optical to X-ray ratio $\log\nu L_\nu/\log\nu L_{1keV}$=5.8, compared to 6.0 for soft X-ray-selected AGN, and 5.9 for hard X-ray-selected AGN (Grupe 1996). The infra-red to X-ray ratios are low, with $\nu L_{60\mu}/\nu L_{1keV}$=1.1 and $\nu L_{12\mu}/\nu L_{1keV}$=3.72. For soft X-ray selected AGN Grupe (1996) finds corresponding values of 8.3 and 12.0; for hard X-ray selected AGN the values are 3.7 and 6.5. Thus LB 1727 seems X-ray-bright compared to the infra-red flux. This suggest that if dust is important in this source, then it is not reprocessing much of the nuclear radiation.

8. Discussion

The X-ray spectrum of LB 1727 is flat in the $\sim 0.7 - 10$ keV range, with $\Gamma = 1.5 - 1.6$. The source shows no evidence for intrinsic absorption by neutral material. There are several examples of flat X-ray (2-10 keV) spectra reported for Seyfert galaxies (NGC 4151, e.g. Weaver et al. 1994; NGC 3227, e.g. George et al. 1998), however, in most known cases these active nuclei are heavily absorbed. The relationship (if any) between spectral index and absorption is unknown, but it is interesting to find examples of flat, but apparently unabsorbed, nuclear spectra. The observation of a flat continuum does not appear to be an artifact of confusion between continuum and Compton reflection, as fits including a strong reflection component still required a flat underlying continumm (although we cannot rule out the presence of some contribution from reflection). The line appears broad, and the energy is consistent with an origin in neutral material, but the shape and parameters cannot be well-constrained.

The X-ray spectrum steepens sharply below 0.7 keV (rest-frame). The soft X-ray spectrum has a slope $\Gamma \sim 3.2$, and if the nucleus is unattenuated then the PSPC data constrain the spectral break to occur at a rest-energy 0.7 ± 0.08 keV. The fact that the spectral break occurs at the same energy in the PSPC and *ASCA* observations is intriguing. The PSPC found the source to be brighter and steeper than it was during the *ASCA* epochs. If this was due to an increase in the normalization of the XUV-bump, then one would expect the break to move to higher energy as the XUV-bump increased in relative strength. The apparent constancy of the break-energy is indicative that the break itself is attributable to opacity effects and depends on the ionization-state of the gas. Thus it is interesting to consider the limits on the presence of ionized gas. The data are consistent with a column density $N_H^* \sim 10^{22}\mathrm{cm}^{-2}$ of highly ionized gas ($U_X \sim 2$) which may contribute to the spectral steepening below 0.7 keV. While ionized material can yield a spectral softening such as that observed in the *ASCA* data, a simultaneous HRI data point suggests the underlying contionuum must also steepen significantly. This picture is supported by the marked steepening observed in the PSPC data, the bright *EUVE* flux and the shape of the optical continuum. Thus the presence of an XUV continuum bump seems likely, dominating the ultraviolet-to-soft-X-ray regime. However, if the observed spectral break is due in some part to the presence of ionized material along the line-of-sight, the break energy of the underlying continuum can only be said to occur between 0.1 and 0.7 keV.

LB 1727 resembles the Seyfert 1 galaxy Mrk 841 in many ways. Mrk 841 shows a two-component X-ray spectrum, with a variable slope in the 2–10 keV band, that slope has been observed to be as flat as that reported here. The soft X-ray regime in that Mrk 841 is also dominated by a steep component.
I will compare the SEDs of these two

The XUV-bump must be a source of copious ionizing photons, which might be expected to have a noticable effect on optical line ratios. As discussed by Cohen (1983) and Kramer et al. (1998), the HeIIλ4686/Hβ ratio should depend strongly on the XUV spectrum, examination of the narrow components of these lines is instructive as the NLR is free from the strong collisional effects affecting the BLR. In fact, Kraemer et al. (1998) find some evidence for a relationship between the presence of a soft continuum component and the ratio of narrow HeIIλ4686/Hβ, such that sources showing a steep spectrum in the soft X-ray regime have a relatively large line ratio. In their analysis, LB 1727 has a strong HeII contribution and a strong soft X-ray flux, as might be expected if the XUV component is significant in ionizing the NLR gas. The optical data show some evidence of attenuation, the Balmer decrement infers a mean attenuation to the broad and narrow-line-regions of $N_H \sim 2 \times 10^{21}\mathrm{cm}^{-2}$. A column of ionized, dusty material would be consistent with data in both regimes. Alternatively, the gas which obscures the regions producing optical lines may simply be out of the line-of-sight to the nucleus. The *ASCA* data also reveal an emission line from the K-shell of iron.

9. Acknowledgements

We are grateful to *ASCA* team for their operation of the satellite. This research has made use of the NASA/IPAC Extragalactic database, which is operated by the Jet Propulsion Laboratory, Caltech, under contract with NASA; of the Simbad database, operated at CDS, Strasbourg, France; and data obtained through the HEASARC on-line service, provided by NASA/GSFC. We acknowledge the financial support of Universities Space Research Association (IMG, TJT) and the National Research Council (KN).

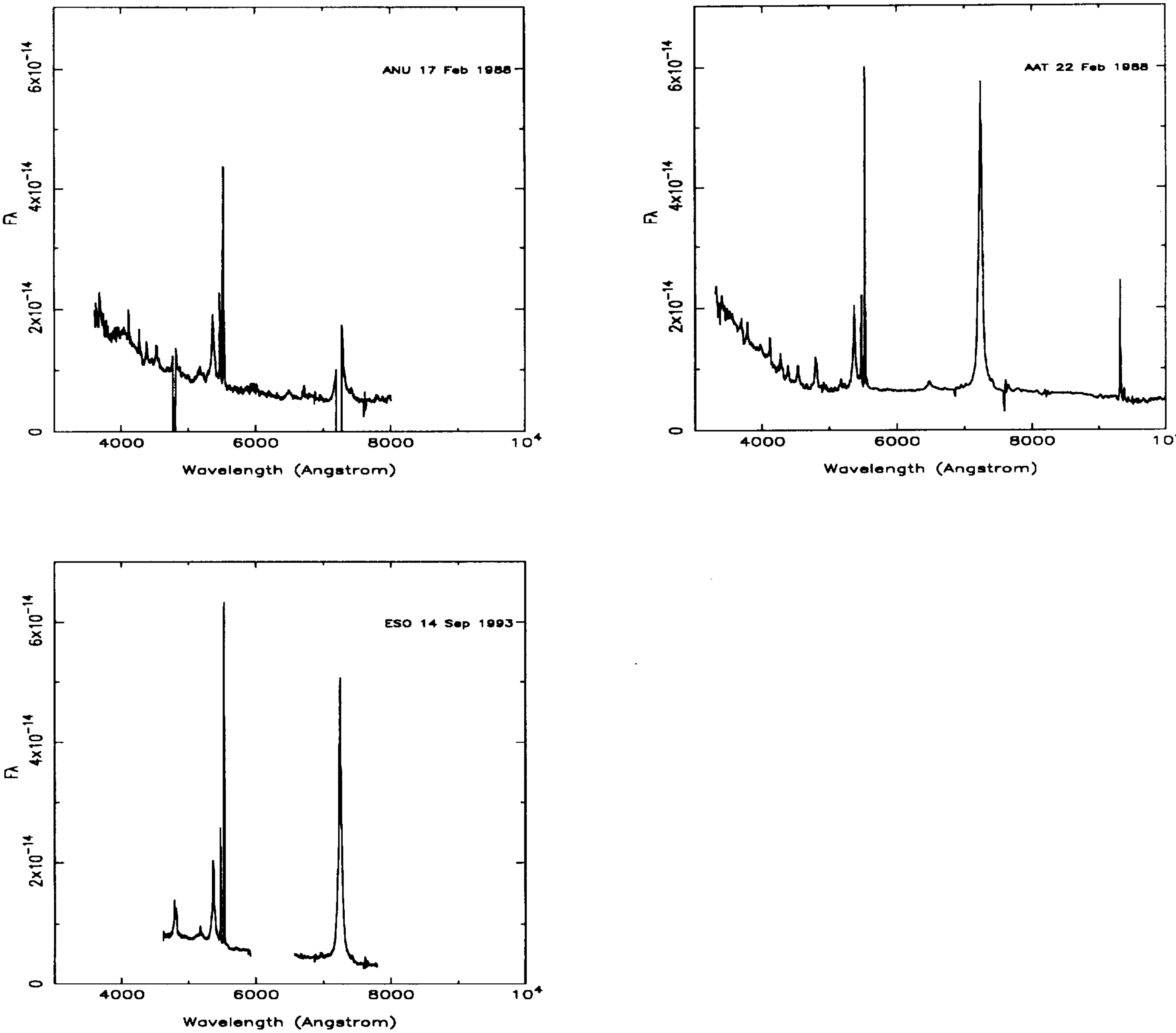

Fig. 1.— Optical spectra of LB 1727.

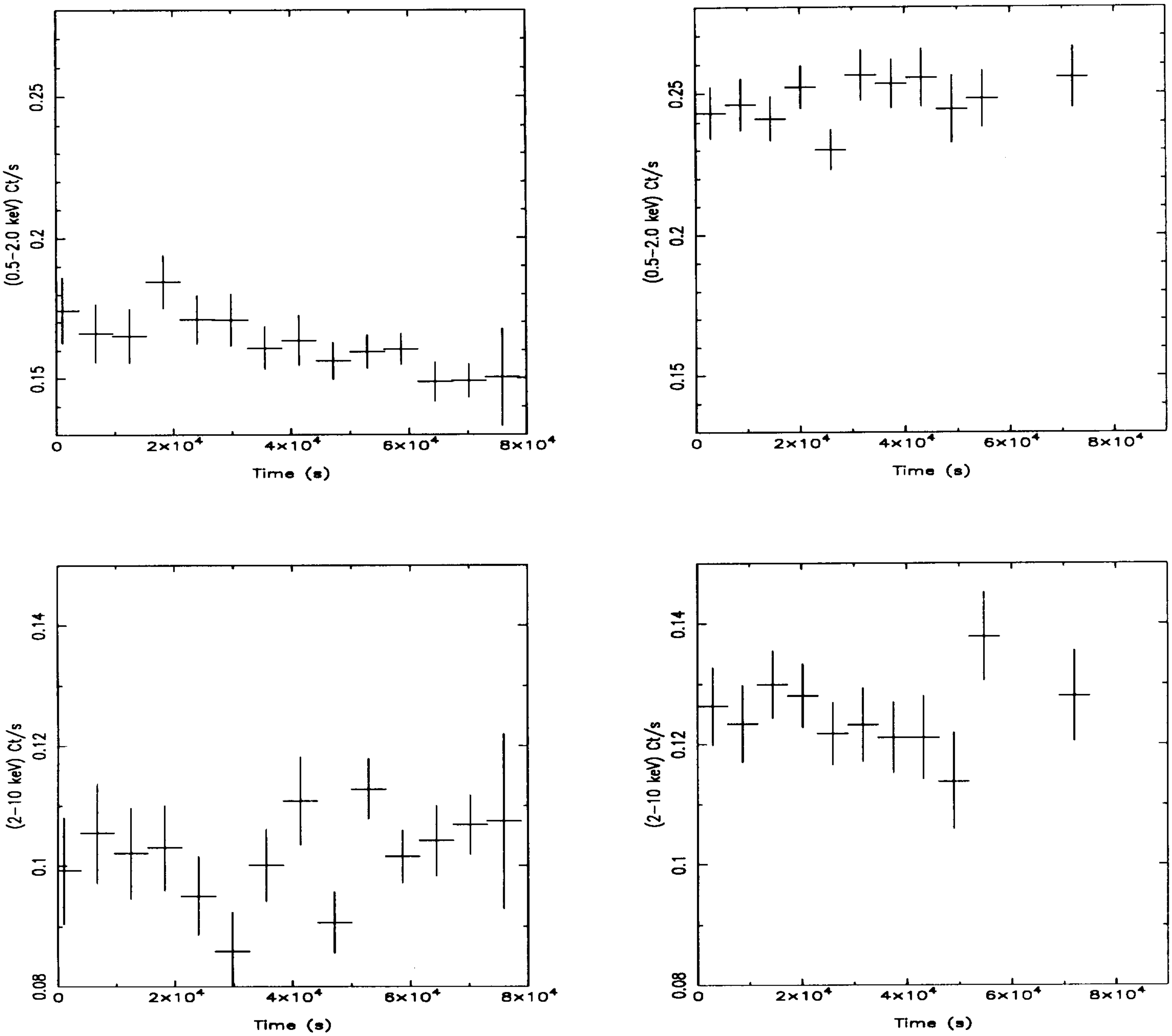

Fig. 2.— The light curves in 5760 s bins for the combined SIS data in the observed-frame 0.5-2 keV band and 2-10 keV band for the 1996 July and 1996 August data.

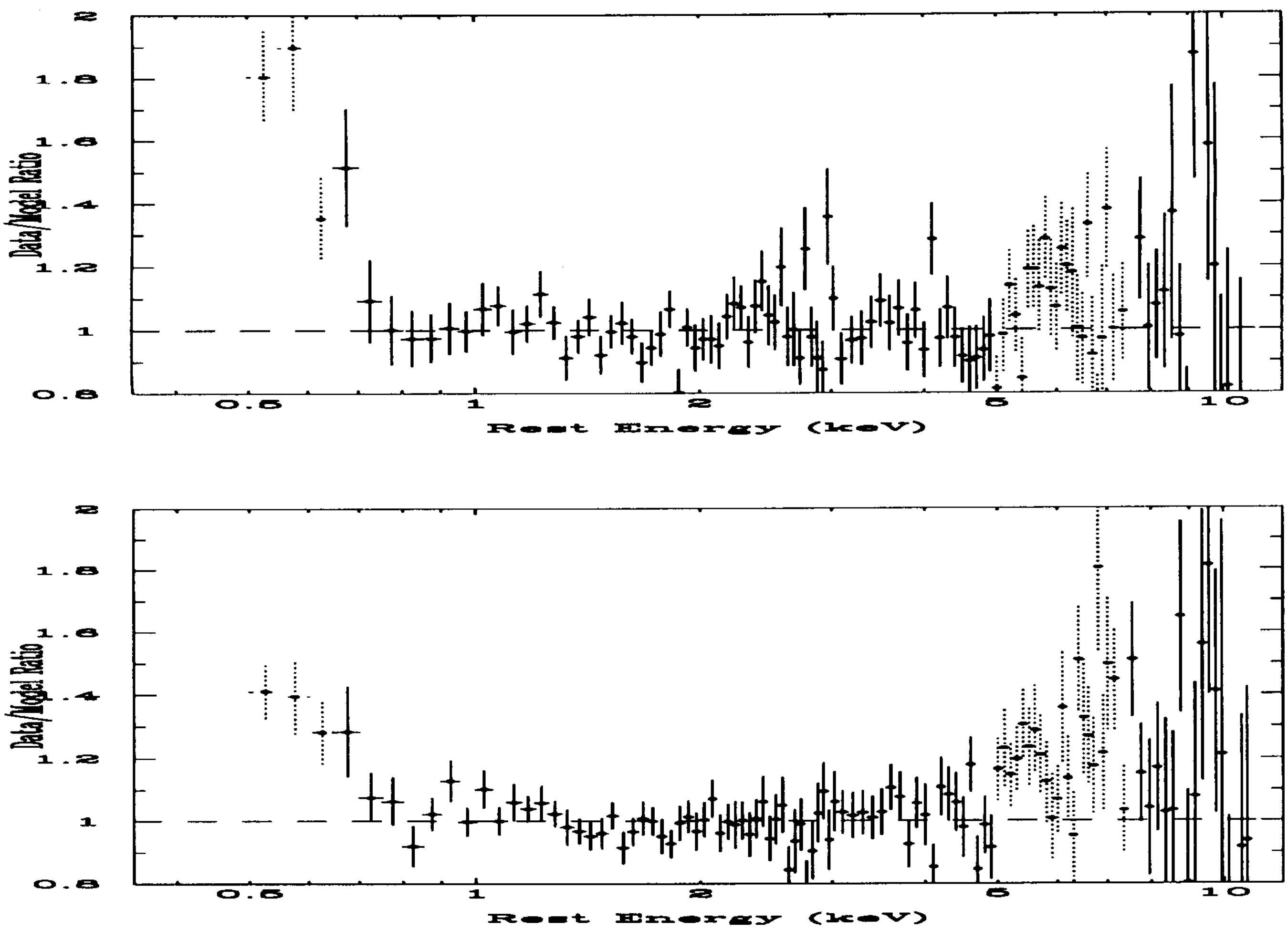

Fig. 3.— The data/model ratio from the combined SIS+GIS data, compared to a power-law model. The dotted points show the SIS data from the 0.4-0.6 keV band, which were not used in the fit but have been overlaid for illustrative purposes. Data are compared to power-law model with absorption by a column of neutral material, fixed at the Galactic line-of-sight value. a) July 1996 data, b) August 1996 data.

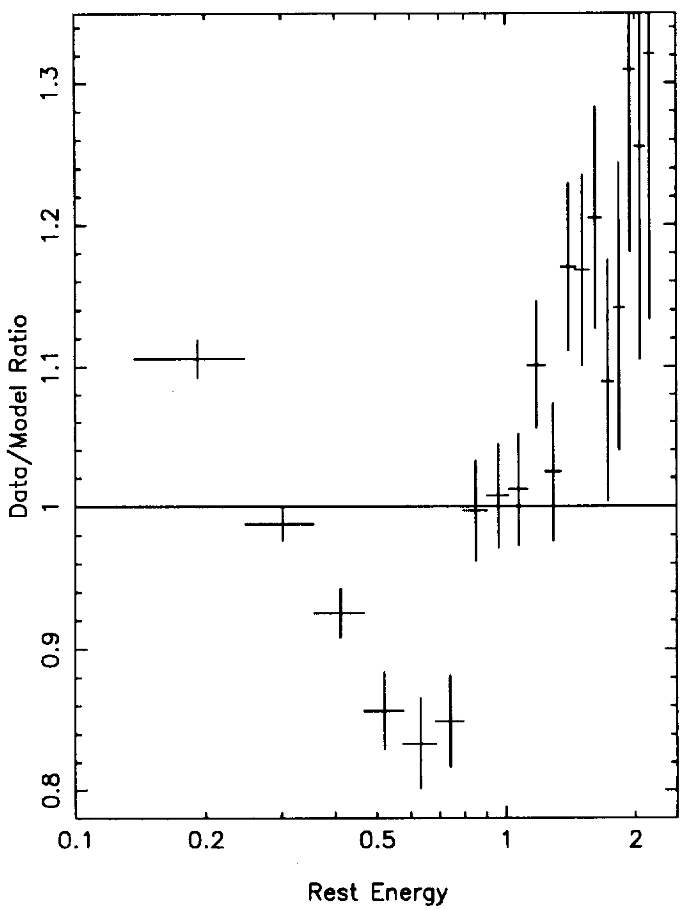

Fig. 4.— The data/model ratio from the *ROSAT* PSPC data, compared to a power-law model, allowing attenuation by an unconstrained column of neutral material, showing the spectral break at a rest-frame energy of 0.7 keV.

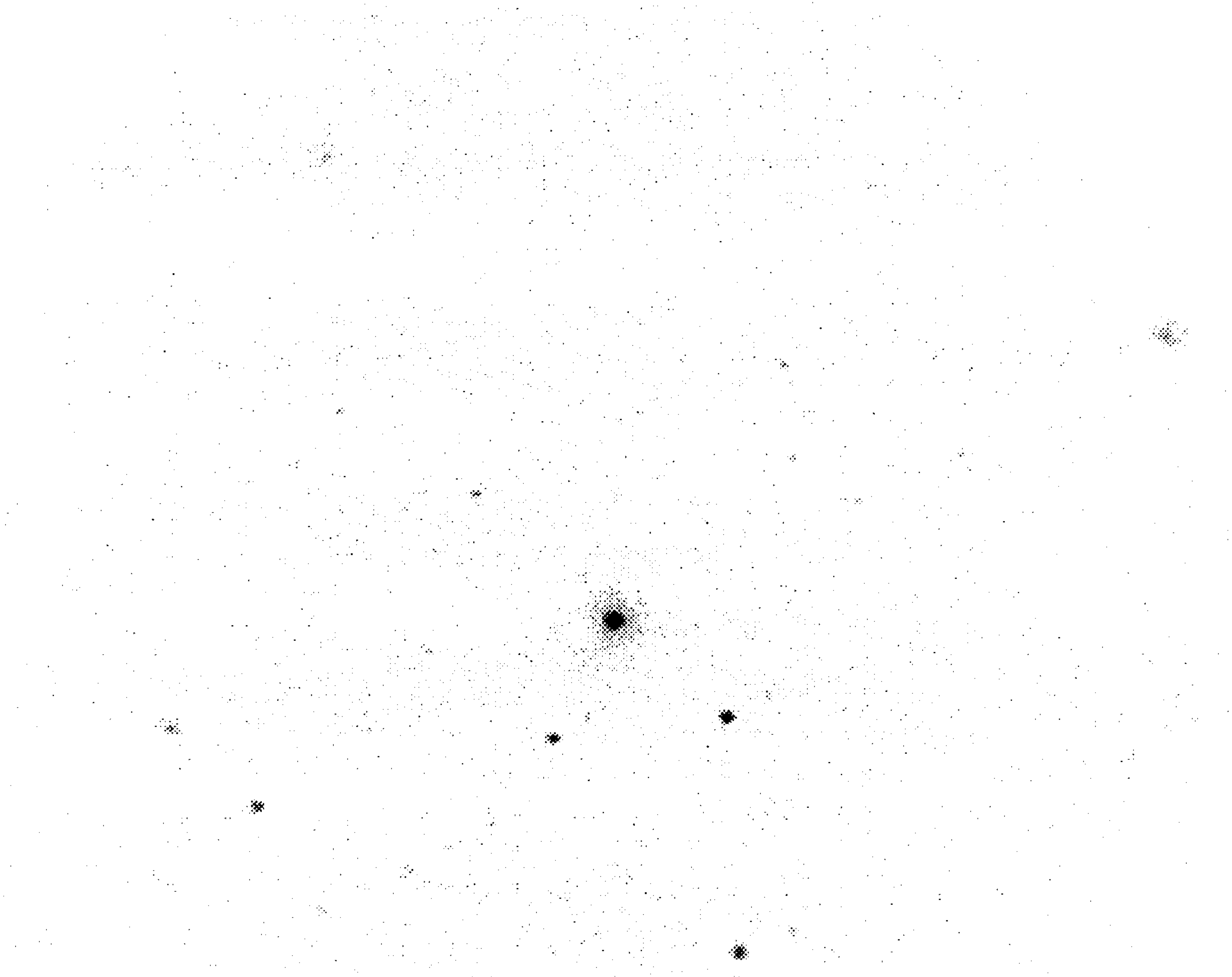

Fig. 5.— The HRI image, LB 1727 is the bright source at the center. There is no strong X-ray source evident which could have contaminated the *ASCA* data. The full field-of-view of the HRI is shown, which has a diameter of $40'$.

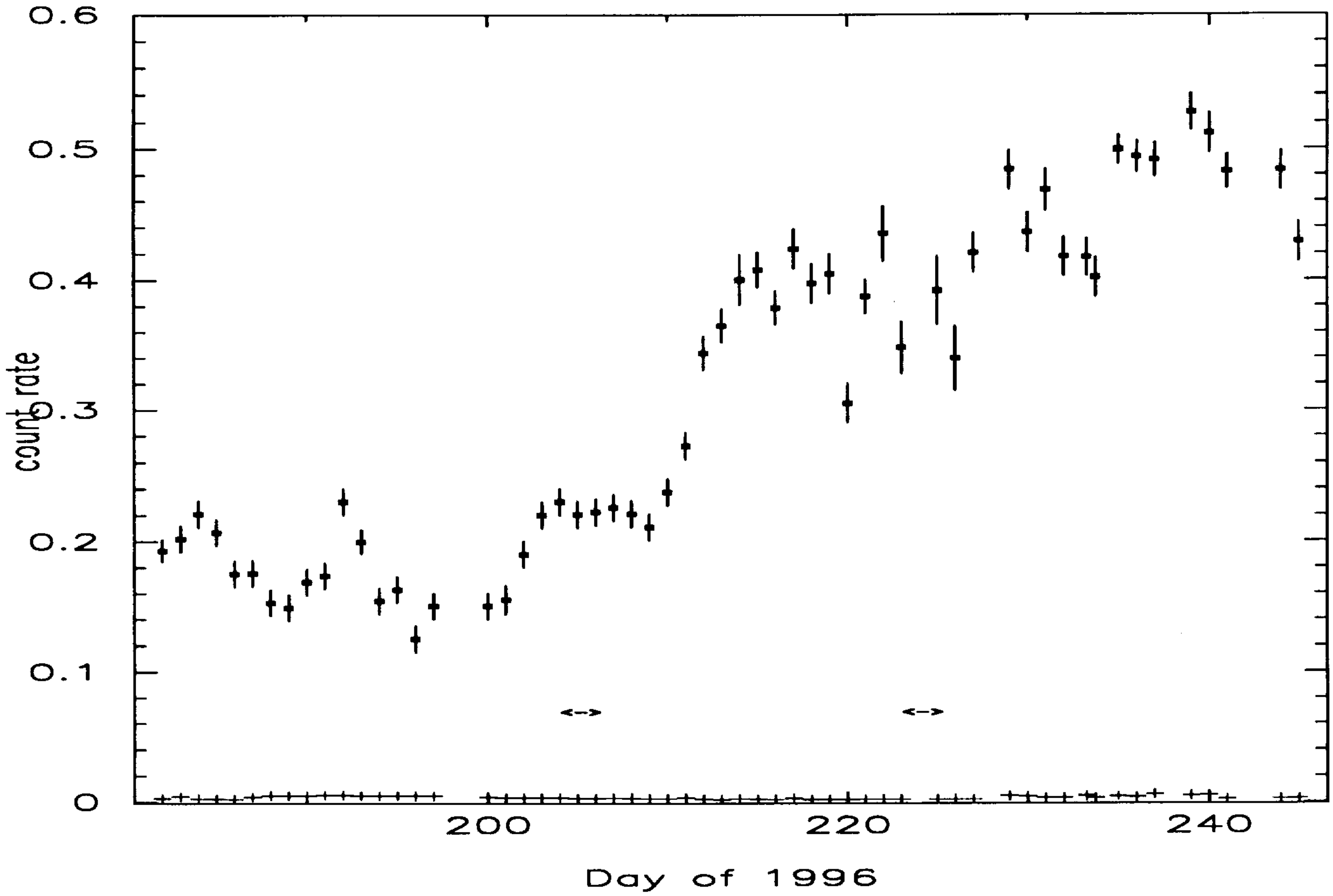

Fig. 6.— The HRI light curve, showing the source count rate taken from a cell of 30" radius, encompassing 90% of the source counts. The background level in the source cell is shown with crosses. The two small arrows show the periods when *ASCA* was observing the source.

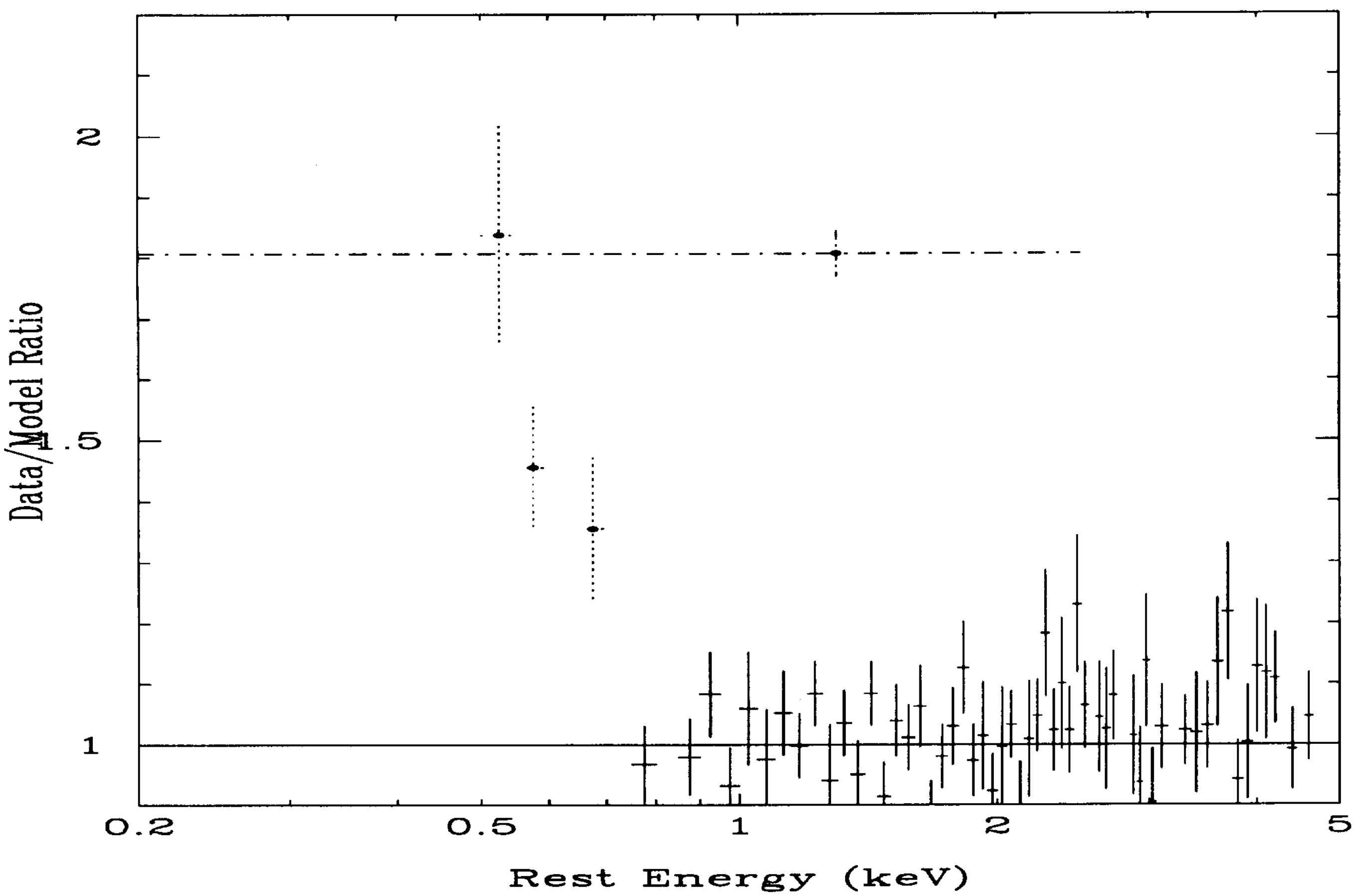

Fig. 7.— The ratio of the ASCA data and simultaneous HRI data to a model of a power-law attenuated by an ionized absorber, after fitting the *ASCA* data (above 0.6 keV). The *ASCA* data bewlo an observers-frame of 0.6 keV are shown as dotted lines, as these were not used in the fit. The HRI data are shown as a dashed point. Fitting this HRI point simultaneously with the *ASCA* data did not yield an acceptable fit (see text for details).

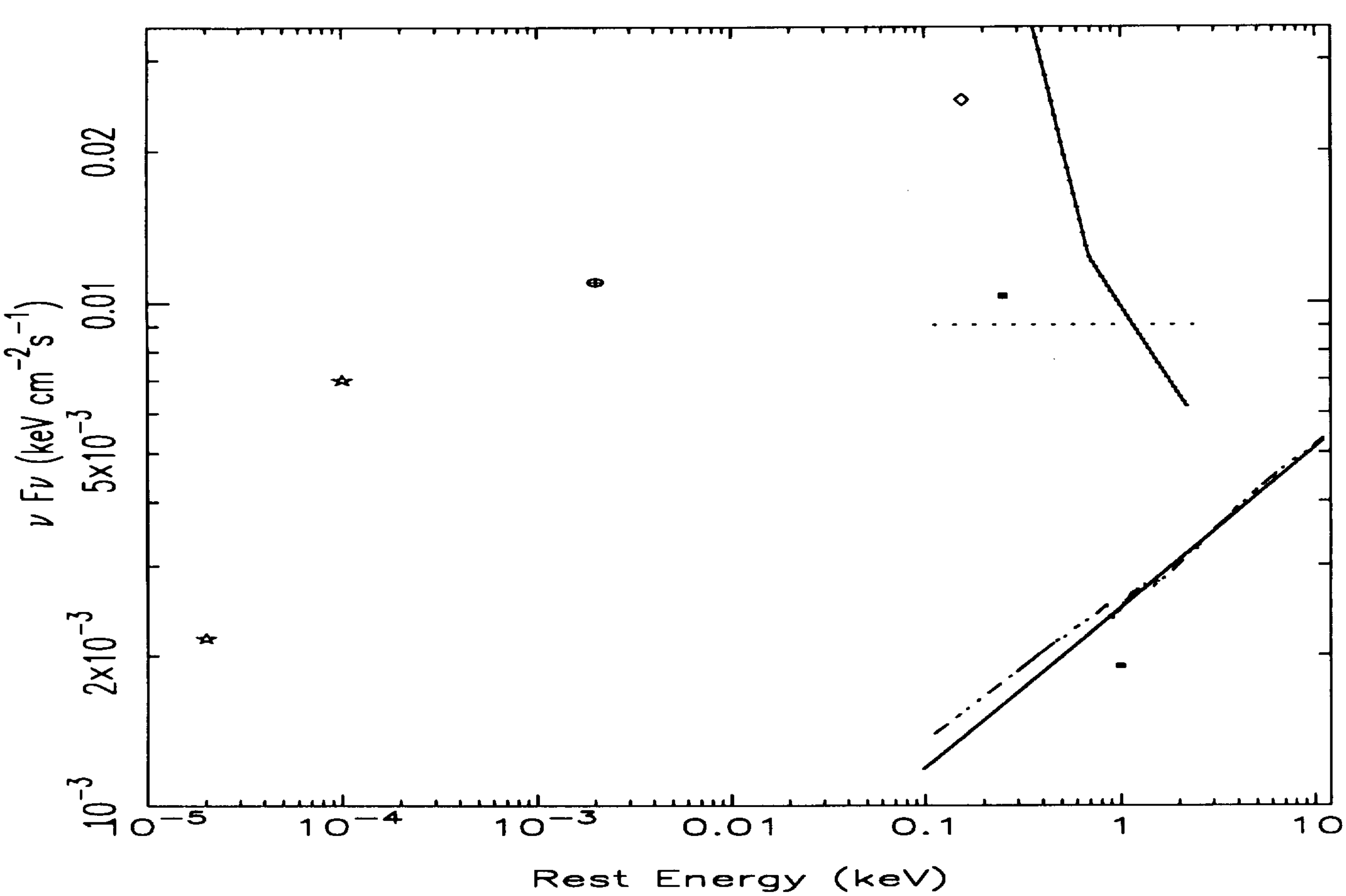

Fig. 8.— Two models for the *ASCA* data, compared to the absorption-corrected *EUVE* data (open diamond); the *ROSAT* PSPC data (dot-dash line); the 60 and 12 micron fluxes (stars, Grupe 1995); the optical flux (open circle, Grupe 1996) and the *ROSAT* all-sky survey fluxes (filled boxes, Grupe 1996). The solid model line represents the best-fit power-law model and the dotted line represents the best-fit power-law with attenuation by a column of ionized material (see text for details), both based upon the August 1996 *ASCA* data.

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13. ABSTRACT *(Maximum 200 words)*
We discuss the properties of the Seyfert 1.5 galaxy LB 1727 based upon the analysis of two *ASCA* observations, a two-month *Rosat* monitoring campaign, and optical data. The target is identified with the HEAO-A1 source 1HO419-577, so it has been observed by *ASCA* and *ROSAT* in order to obtain better X-ray variability and spectra data. Only modest (20%) variability is observed within or between *ASCA* and *BeppoSAX* observations in the ~ 2 – 10 keV band. However, the soft X-ray flux increased by a factor of 3 over a period of 2 months, while it was monitored daily by the *ROSAT* HRI instrument. The hard X-ray continuum can be parameterized as a power-law of slope $\Gamma \sim 1.5 - 1.6$ across 9.7 – 11 keV in the rest-frame. We also report the first detection of an iron Kα line in this source, consistent with emission from neutral material. The X-ray spectrum steepens sharply below 0.7 keV yielding a power-law of slope $\Gamma \sim 3.2$. There is no evidence for absorption by neutral material, instrinsic to the nucleus. If the nucleus is unattenuated, then the break energy between the soft-excess and hard component is 0.7 ± 0.08 keV. An ionized absorber may produce some turn-up in the spectrum at low energies, but a steepening of the underlying continuum is also required to explain the simultaneous *ASCA* and HRI data. We cannot rule out the possibility that a significant column of ionized material exists in the line-of-sight, if that is true, then the continuum break-energy can only be constrained to lie within the ~0.1 – –0.7 keV band.

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