THE SOFT X-RAY EMISSION FROM ON 235 AND MK 766

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1. Introduction

BL Lac objects have been shown to be a class of powerful X-ray sources (Schwartz et al. 1979; Maccagni and Tarenghi 1981; Schwartz, Madejski and Ku 1982). Furthermore, the lack of intrinsic absorption suggested by the extreme weakness of emission lines makes these objects particularly suitable candidates for observation in the soft X-ray band. In the framework of a program of extensive monitoring of BL Lac objects, we obtained a 460 min exposure of ON 235 with the EXOSAT Observatory. The same CMA field contains also the X-ray emitting Seyfert 1 galaxy MK 766 (Kriss, Canizares and Ricker 1980), which lies about 20 arcmin S of ON 235.

2. Observations and Data Analysis

The observation took place on 1983 December 19. The LE telescope 1 CMA was used in conjunction with the thin lexan, aluminum/parylene and boron filters. In Table 1 the results of the observation are summarized.

a) X-ray Positions

The 1950 X-ray coordinates are obtained by computing the angular distance of the centroid of each source from the pointing direction and by converting to celestial coordinates taking into account the roll angle of the observation. They are in excellent agreement with the optical positions.

b) Counting Rates

We adopted the rather standard procedure to obtain counting rates from X-ray imaging instruments. Concentric circles are drawn centered on the source centroid and photon density profiles are constructed. The background is then estimated from the density level beyond 40 pixels (160 arcsec) and then subtracted from the counts inside each radius. The counting rate is then obtained from the number of counts inside the radius where the ratio of signal to noise is maximum, by dividing by the exposure time and correcting for the Point Spread Function (PSF). Of

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TABLE 1

1950 Coordinates

		ON 235	MK 766
Optical Position	α δ	$12^h15^m21^s$ $30^o23'39''$ (a)	$12^h15^m36^s$ $30^o05'$ (b)
X-ray Position	α δ	$12^h15^m21^s.31$ $30^o23'32''.00$	$12^h15^m56^s.24$ $30^o05'36''.00$

Filter	Exposure Time (sec)	Counting Rate (counts s^{-1}) ON 235	MK 766
Lexan3	2805	$(7.84 \pm 0.59)\times10^{-2}$	$(2.77 \pm 0.11)\times10^{-1}$
Al-Par	5199	$(3.29 \pm 0.29)\times10^{-2}$	$(1.68 \pm 0.06)\times10^{-1}$
Boron	19613	$(2.61 \pm 0.59)\times10^{-3}$	$(1.76 \pm 0.14)\times10^{-2}$

(a) Craine 1977
(b) Weedman 1978

course, we did first check for the agreement between the source profile and the given PSF. There are no problems for ON 235 which was in the center of the field of view, while in the case of MK 766 we adopted a PSF with a FWHM of twice as many pixels. This off-center PSF gives a very good agreement with the source profile and is fully compatible with the calibrations for the position of this source in the field of view. The errors quoted in Table 1 are statistical errors only and include the background subtraction.

c) Spectral Fitting

The assumed spectrum determines the counting rates in the different filters. In the case of AGNs, it is commonplace to assume a power law spectrum with two parameters: the hydrogen column density N_H and the energy spectral index α. In the present case, we have to simultaneously satisfy the following three statistical equations:

$$C_i \pm \Delta C_i = K \int_{E_{min}}^{E_{max}} E^{-(\alpha+1)} f(N_H,E)\, \varepsilon_i(E)\, dE$$

where i is the filter index, $f(N_H,E)$ is the absorption law (we have used the Gould model extended toward the UV), $\varepsilon_i(E)$ are the filter effective

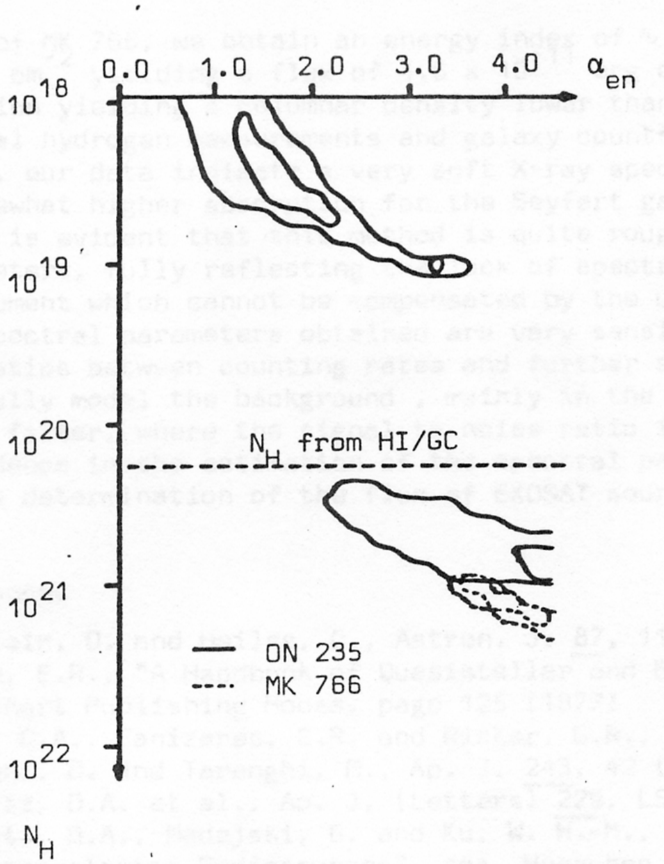

Figure 1

areas and E_{min} and E_{max} the energy boundaries of the telescope+detector sensitivity (we have taken E_{min} = 0.02 keV and E_{max} = 2.0 keV). In practice, we determined α and N_H by requiring that the three ratios that can be computed from the counting rates in the different filters are simultaneously satisfied within a certain number of times their statistical errors. The results of this procedure are illustrated in Figure 1, where 1 and 2 σ contours show the values of the spectral parameters (under the assumption of a power law) simultaneously satisfying the observed ratios. The flux in the EXOSAT bandwidth can then be obtained from any of the counting rates by taking the acceptable values of α and N_H.

3. Discussion and Conclusions

From a simple inspection of Figure 1 we can immediately see that the solutions to the problem of obtaining spectral information (but also an integral flux compatible with all the three counting rates) is by no means unique and leads to somewhat puzzling results. For ON 235 we have two possibilities (at least in the portion of parameter space we explored): the data leave us free to decide between a power law spectrum with energy index $\sim$1.7 and $N_H \sim 2.4 \times 10^{18}$ atoms cm^{-2} (yielding a flux of 2.7×10^{-12} erg cm^{-2} s^{-1}) and a power law spectrum with energy index $\sim$ 4.3 and $N_H \sim 6.2 \times 10^{20}$ atoms cm^{-2} (yielding a flux of 7.9×10^{-12} erg cm^{-2} s^{-1}). In the case of MK 766, we obtain an energy index of ~ 4.0 and $N_H \sim 1.2 \times 10^{21}$ atoms cm^{-2} yielding a flux of 4.6×10^{-11} erg $cm^{-2} s^{-1}$. If we reject the solution yielding a columnar density lower than what can be inferred from neutral hydrogen measurements and galaxy counts (Burnstein and Heiles 1982), our data indicate a very soft X-ray spectrum for both sources and a somewhat higher absorption for the Seyfert galaxy.

It is evident that this method is quite rough in estimating the spectral parameters, fully reflecting the lack of spectral resolution of the instrument which cannot be compensated by the use of broad band filters. The spectral parameters obtained are very sensitive to small variations in the ratios between counting rates and further steps in the analysis must carefully model the background , mainly in the observations with the boron filter, where the signal to noise ratio is lower, in order to gain confidence in the estimation of the spectral parameters and consequently, in the determination of the flux of EXOSAT sources.

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