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EXOSAT OBSERVATIONS OF 3C 371

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ABSTRACT

The N galaxy/BL Lacertae object 3C 371 was observed by *EXOSAT* on two occasions separated by 18 days in 1984 September. The low-energy and medium-energy X-ray flux has varied on the time scale of years (in comparison with *HEAO 1* and *Einstein Observatory* measurements), 18 days (between our two observations), and 8 hr to ~25 minutes within our first observation. We have determined the 0.05–6 keV energy spectrum using data acquired during the first observation with the low-energy telescope and channeltron matrix array detector (LE) and medium-energy proportional counters (ME). We find that the spectrum probably consists of two components, with the steeper one at low photon energies.

Subject headings: BL Lacertae objects — galaxies: individual — galaxies: nuclei — X-rays: sources

I. INTRODUCTION

The AGN 3C 371 has a number of interesting features, made possible for study due to the relative brightness of the source [$m_v \approx 14$ mag and S(5 GHz) ≈ 2 Jy]. It is embedded in a well-studied galaxy which provides the redshift of 0.05 for the system (Sandage 1973). Although optical spectral features are weak (Miller 1975), it has been found to exhibit strong Lyman-α emission (Worrall *et al.* 1984) indicating the presence of photoionized gas. Apart from the gas and galaxy components, the composite emission spectrum from radio to X-ray wavelengths closely resembles that of a BL Lac–type nucleus and has been interpreted using synchrotron and synchrotron self-Compton (SSC) emission models (Perley and Johnston 1979; Snyder *et al.* 1982; Worrall *et al.* 1984). VLBI and VLA radio maps show jet structures which are presumed to be continuous, and 3C 371 is understood to be a good candidate for superluminal motion (Pearson, Perley, and Readhead 1985), with some VLBI evidence that superluminal motion is actually exhibited (Readhead, Pearson, and Unwin 1984). The SSC model fits to the composite spectrum and time-variability data by Worrall *et al.* (1984), based on the jet model of Königl (1981), require the source to be relativistically beamed and predict X-ray variability on a time scale of ~1 hr at 0.4 keV.

Two X-ray observations of 3C 371 with the *Einstein Observatory* Imaging Proportional Counter (IPC), separated by about 17 months, measured the same intensity, to within about 30% errors, and were too short to test for variability on an hourly time scale (Worrall *et al.* 1984). X-ray variations over 1–2 weeks had been previously reported by Snyder *et al.* (1982), but using a nonimaging detector. We report here two *EXOSAT* observations of 3C 371 which confirm variability over time scales of 2 weeks and greater, and also exhibit variability on shorter time scales, down to ~25 minutes. We also present the first X-ray spectrum of 3C 371.

II. OBSERVATIONS

The source 3C 371 was observed with *EXOSAT* for 12 hr on 1984 September 11/12 (observation 1) and for 7.5 hr on 1984 September 29/30 (observation 2). The source was observed simultaneously with (*a*) the imaging LE1 telescope with channeltron matrix array (CMA) detector (LE) with a sequence of different absorption filters covering the range 0.05–2 keV, (*b*) the medium-energy proportional counters (ME) with 0°75 (FWHM) collimators for the range 2–20 keV, and (*c*) the gas scintillation proportional counter (GSPC). Taylor *et al.* (1981) describe these instruments. The source was too weak to be detected by the GSPC. We report here the spectral and temporal analysis of the LE and ME data.

For observation 1, the sequence of LE filters was thin Lexan (3LX), A1/Parylene, boron, and thin Lexan. The filter sequence for observation 2 was thin Lexan, Polypropylene, A1/Parylene, and thin Lexan. We omitted the boron filter because the source intensity was lower than for the first observation, and our observing time was shorter. Instead, we performed a short Polypropylene observation which confirmed negligible UV contamination during the observation. A second X-ray source was detected with the LE about 20′ southeast of 3C 371 in both observations. Worrall *et al.* (1984) discovered this X-ray source with the *Einstein Observatory* IPC and suggested its identification with a K star.

Net count rates for 3C 371 for each filter were calculated by summing the number of events within a circle of radius 40″ centered on the source and applying the appropriate point response function. A correction was made to the source counts with the boron filter due to the enlarged point response function (Davelaar and Giommi 1985). The background rate was determined from a source-centered annulus with radii 160″ and 400″.

The standard ME operating procedure was used in both observations, by which only two of the four quadrants pointed toward the target while the other two pointed ~2° away to provide a background count rate. Detector switching was used so that each set of two detectors spent two intervals pointing at 3C 371 and two intervals of similar length pointing at background.

Between 4 and 6.4 hr from the beginning of observation 1, all four ME detectors recorded excess particle background which we presume to be due to solar flaring. We have excluded data

TABLE 1

EXOSAT LOW-ENERGY OBSERVATIONS OF 3C 371

	OBSERVATION 1: 1984 SEP 11.85–12.35 UT		OBSERVATION 2: 1984 SEP 29.97–30.28 UT	
FILTER[a]	Integration Time (hr)	Count Rate[b] (10^{-2} s^{-1})	Integration Time (hr)	Count Rate[b] (10^{-2} s^{-1})
3LX(1)	5.54	6.19 ± 0.23	3.37	2.72 ± 0.20
PP..............	...	...	0.65	2.58 ± 0.45
A1/P	1.89	3.05 ± 0.31	1.70	1.36 ± 0.22
Boron	2.08	0.42 ± 0.16	...	...
3LX(2)	2.36	4.68 ± 0.31	1.66	2.47 ± 0.29
3LX	7.90	5.65 ± 0.18	5.03	2.64 ± 0.16

[a] 3LX = thin Lexan; PP = Polypropylene, A1/P = Aluminum/Parylene.

[b] Count rates are corrected for dead time, partial flap coverage, and scattering point-spread function.

during these times from our ME spectral analysis (§ III). Further discussion of data during this period is presented in § IV.

III. *EXOSAT* X-RAY SPECTRUM OF 3C 371

The boron, A1/Parylene, and thin Lexan filters are transparent to photons of sufficiently different energy that we can attempt a spectral fit to the LE data for observation 1. Net count rates are given in Table 1. The average count rate of the LE with the thin Lexan filter showed a 4 σ significance decrease of 24% in the 8 hr interval between our two measurements (see § IV). We have averaged the LE/thin Lexan count rate over the whole of observation 1 in fitting the spectrum.

Assuming a power law, we determine the three spectral parameters from the three observed filter count rates (with zero degrees of freedom); energy index $\alpha = 2.4$, neutral hydrogen column density $N_H = 5.3 \times 10^{20}$ atoms cm^{-2}, and normalization at 1 keV A = 2.0×10^{-3} keV cm^{-2} s^{-1} keV^{-1}. We note that the column density so determined is quite close to the galactic value found from 21 cm observations; an interpolation of nine radio pointings within 2° of 3C 371 (Stark *et al.* 1986) yields 5.0×10^{20} atoms cm^{-2}. We adopt this value as a lower limit for our further analysis (see also discussion below). We can then set a limit on the column density intrinsic to 3C 371 by determining the increase in N_H which renders χ^2 unacceptable. We find an increase in χ^2 of 3.8 when N_H is 1.7×10^{21} atoms cm^{-2}, implying a 95% confidence upper limit to the intrinsic column density of 1.2×10^{21} atoms cm^{-2}. When the column density is set to the Galactic value of 5.0×10^{20} atoms cm^{-2}, our acceptable best spectral fit is $2.0 \times 10^{-3}E^{-2.4}$ keV cm^{-2} s^{-1} keV^{-1}.

The ME does not usefully constrain N_H, so we have set it to the galactic value, as above. The ME data for observation 1 give an acceptable best fit to a power law of $3.3 \times 10^{-3}E^{-1.4}$ keV cm^{-2} s^{-1} keV^{-1}. The fit is shown in Figure 1 for each detector half (ME1 and ME2) separately. The unequal sta-

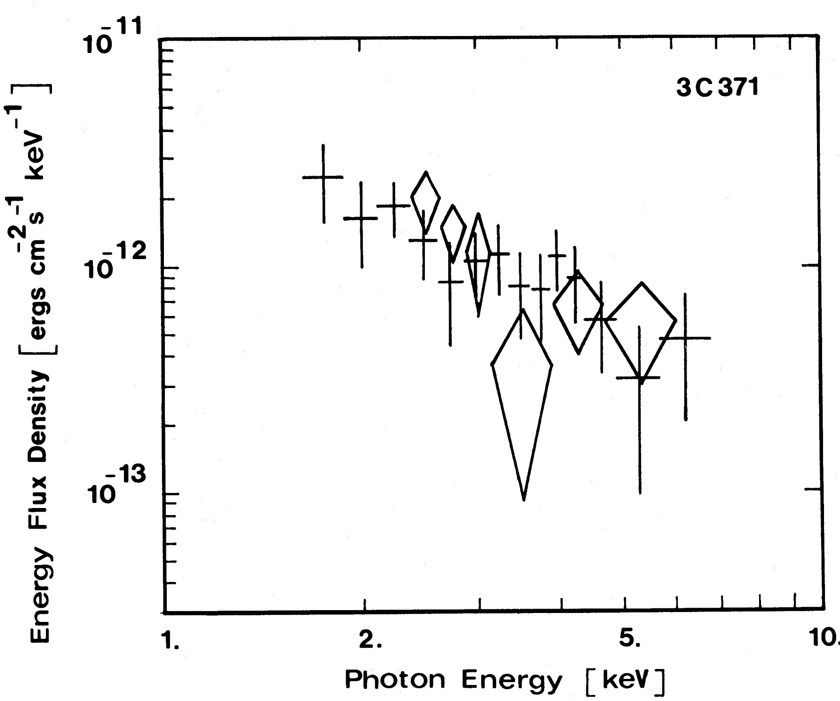

FIG. 1.—ME energy spectrum of 3C 371 from *EXOSAT* observations of 1984 September 11/12. The ME2 detector half (*diamonds*) gives poorer statistical quality than the ME1 detector half (*crosses*) due to exclusion of data during a period of excess background. The best-fit power-law energy index is $\alpha = 1.4$.

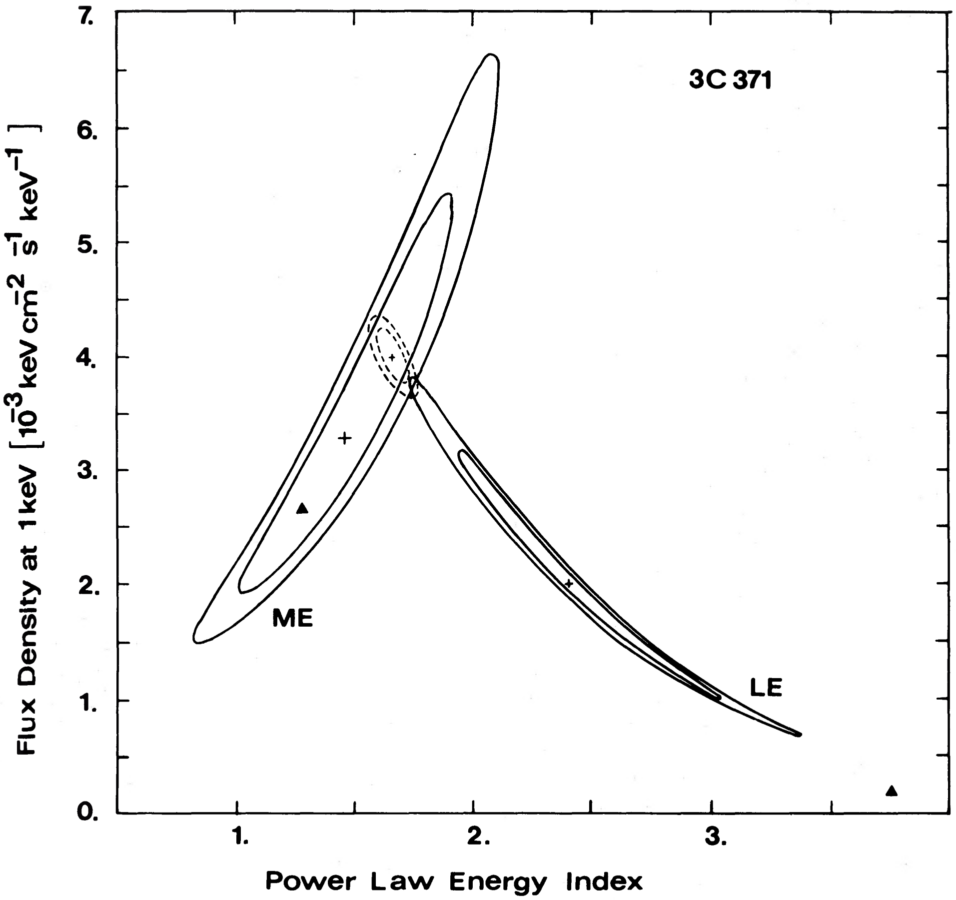

FIG. 2.—Solid curves are 68% and 90% joint confidence contours (χ^2_{min} + 2.3 and χ^2_{min} + 4.6) for power-law fits to the LE and ME data fitted separately. Broken curves are the same for simultaneous fits to the LE and ME data with a single power law (H0), and triangles are the best-fit parameter pairs for two power laws with individual normalization (H2; see text and Table 2 for explanation). N_H was fixed to the Galactic value of 5×10^{20} atoms cm^{-2}.

tistical quality is due to the exclusion of data for the two ME2 detectors during the period of excess background mentioned in § II.

In Figure 2 we show confidence contours for power-law fits to the LE and ME data fit separately, as described above. The solid curves are the 68% and 90% joint confidence contours (corresponding to $\chi^2_{min} + 2.3$ and $\chi^2_{min} + 4.6$). The 68% contours are well separated, and the 90% contours overlap only slightly. We take this as an indication of the possible presence of a two-component spectrum, with an excess of soft X-rays. In order to test this, we have performed a series of simultaneous fits to the LE and ME data, the results of which are summarized in Table 2. We start with the simplest model (H0), a single power law. The fit is formally acceptable. However, the contributions to the overall χ^2 from the LE and ME are quite asymmetric: 4.9 from three LE data points and 9.5 from 20 ME data points. Introducing one more adjustable parameter, we go to two power laws with a common normalization (model H1) and find a reduction in total χ^2 by 3.4 (and now a symmetric contribution to the reduced χ^2). In order to decide whether H1 is a significantly better model than H0, we apply a theorem for testing composite hypothesis originally proposed by Wilks (1938) (see also Brownlee 1965 and, for an application in analysis of astronomical data, Malina, Lampton, and Bowyer 1976). If the improvement in minimum χ^2 values in going from the simple hypothesis H0 with p adjustable parameters to the more complicated hypothesis H1 with $p + r$ adjustable parameters is Δs, one may reject H0 at a significance level $\beta = P(\chi^2_r > \Delta s)$, taken from the χ^2 distribution with r degrees of freedom. Here, in going from H0 to H1 we find $\Delta s = 3.4$, corresponding to a significance level of 7%. This is the probability of wrongly rejecting H0 in favor of H1 (independent of the formal confidences assigned to the fits under H0 and H1). A similar result is obtained with the "test of additional term" described by Bevington (1969), which compares the relative improvement of total χ^2 with an F-distribution: the probability of wrongly rejecting H0 under this test is <2.5%. The next step, from model H1 to model H2, leads to a reduction in χ^2 of only 0.9, corresponding to a significance level of 35%. So, this step is not statistically justified, which means that we are not able to constrain the "crossover energy" very well; that is, we cannot distinguish between a crossover at 1 keV (H1) or 0.35 keV (H2). We note that the separation of the two power-law indices is 1.4 for H1 and 2.5 for H2 (see triangles in Fig. 2), as compared to 1 when the LE and ME data are fitted separately. This is due to the fact that, under models with two power laws, the added fluxes from both components are compared with the observed values, which is important for data points close to the crossover energy, allowing the soft component to be steeper and the hard component to be flatter than in separate fits. We conclude that there is probably a break or flattening in the spectrum, suggested by the improvement in χ^2 when intro-

TABLE 2

SPECTRAL FITS TO *EXOSAT* DATA ON 3C 371

Mode	Number of Adjustable Parameters	Function[a] $A \times E^{-\alpha}$	χ^2_{min}/dof[b,c]
Separate fits to LE and ME data	2	LE: $(2.0 \pm 1.2)E^{-2.4\pm0.6}$	0.02/1
	2	ME: $(3.3 \pm 2.0)E^{-1.4\pm0.5}$	9.2/18
Simultaneous fits to LE and ME data:			
1. Single power law (H0)	2	$(4.0 \pm 0.3)E^{-1.7\pm0.1}$	14.4/21 (4.9, 9.5)
2. Two power laws with one normalization (H1)	3	$(1.5 \pm 0.5)[E^{-(2.4\pm0.4/0.6)} + E^{-(1.0\pm0.6/0.4)}]$	11.0/20 (1.3, 9.7)
3. Two power laws with two normalizations (H2)	4	$0.19E^{-3.8} + 2.7E^{-1.3}$ or $10.3[(E/0.35)^{-3.8} + (E/0.35)^{-1.3}]$	10.1/19 (0.9, 9.3)

NOTES.—(1) Column density for all fits is $N_H = 5 \times 10^{20}$ atoms cm^{-2}. (2) The uncertainties given describe the rectangular boxes enclosing the 68% joint confidence contours (see also Fig. 2). (3) Determination of error limits for model H2 is not meaningful since this corresponds to an attempt to determine error bounds for an additional parameter not really constrained by the data. There is no improvement in reduced χ^2 between models H1 and H2 (see text).

[a] Normalization A at 1 keV in units of 10^{-3} keV cm^{-2} s^{-1} keV^{-1}.

[b,c] LE and ME contributions to χ^2_{min} are in parentheses.

ducing a second power-law component. We cannot be certain, however, about where the break occurs and what the two spectral indices really are. If the two-component model is true, the change in power-law index, somewhere between 0.3 and 2 keV, is most probably 1 (the value found for fits to the LE and ME separately) or larger.

The break becomes more pronounced if the hydrogen column density is assumed to be greater than the galactic value. Some intrinsic column density would be reasonable due to the presence of a galaxy surrounding the bright nucleus of 3C 371, albeit an elliptical galaxy (e.g., Miller 1975). If, on the other hand, N_H is assumed to be much lower than the usual value of 5.0×10^{20} atoms cm^{-2}, no soft X-ray excess is required. There is, however, no reason to believe that this is the case. The galactic coordinates of 3C 371 are $l = 100°$ and $b = +29°$, which points away from the so called "hole" in the interstellar medium (e.g., Frisch and York 1983). The distribution of gas in this general direction, as determined from star spectra in the optical (Paresce 1984) and ultraviolet (Frisch and York 1983), suggest that a column density of 5.6×10^{20} atoms cm^{-2} is reached within a few hundred parsecs of the Sun (for the average of $|b| < 30°$, it is less than 200 pc at $l = 100°$). Indeed, 21 cm measurements by Heiles (1975) and Stark *et al.* (1986) (see above) give just this value for 3C 371, and the corresponding maps do not show structure around the direction to the source. Since the beam width of these radio observations is 2°, we cannot, however, rule out the existence of a very small "hole" in the interstellar neutral hydrogen in the direction to the source. But, we note that several AGNs with a soft X-ray excess have now been found with *EXOSAT* observations (Pounds 1985), and it seems very unlikely that in all of these cases the interstellar medium should have a narrow "hole" at exactly the location of the X-ray source.

The thin Lexan count rate dropped by 24% from the first 5.5 hr observation to the later observation of 2.4 hr (see also Fig. 3). We have used the average Lexan rate to determine the LE spectrum and error contours, since we do not know when the change in the flux occurred. If the individual rates are used instead, the case for a two-component model is stronger for the higher Lexan intensity and less so for the lower intensity.

Any contribution to the ME flux from the X-ray source 20′ from 3C 371 is expected to be negligible. The combination of lower ME effective area and lower thin Lexan count rate imply that it would have been a factor of 5 weaker than 3C 371 in the ME, were its spectrum the same as that of 3C 371. However, its lack of detection in the LE with the boron filter suggests a spectrum steeper than 3C 371, as indeed might be expected were the true identification a K star. This is supported by a reanalysis of the *Einstein* IPC data for the source which suggest a spectrum softer than 3C 371 in the 0.2 to 2 keV energy band.

We are not able to determine the spectrum of 3C 371 for observation 2. The observation time was shorter, and the LE intensity was lower by a factor of 2.2 (see § IV), precluding the use of the boron filter. The ME count rate was so low that a spectral fit could not be made. The ME decrease (0.30 ± 0.023 to 0.18 ± 0.017 counts s^{-1} for ~2–6 keV) is consistent with the same factor, suggesting no large change in spectral shape between the two observations.

IV. *EXOSAT* X-RAY TIME VARIABILITY OF 3C 371

The deadtime-corrected LE net count rates for 3C 371, for integration intervals of 500 s, are shown in Figure 3. The background count rate has been subtracted for each interval individually. It is of the order of 0.006 counts s^{-1} (dashed line in Fig. 3). Since it is dominated by detector background, it does not appreciably vary when filters are changed. Apart from the filter changes which cause changes in count rate, the source shows clear variability (*a*) between observations, (*b*) between the thin Lexan exposures in observation 1, and (*c*) within the first thin Lexan exposure of observation 1. The average count rates with each filter, after additionally correcting for the point-spread function and partial coverage (27%) of the telescope by a flap (which covered the whole telescope at the time of launch and did not fully open), are given in Table 1.

The decrease in LE flux between the observations, separated by 18 days, is a factor of 2.2, consistently found from the Lexan (2.2 ± 0.2) and the Al/Parylene (2.2 ± 0.4) count rates. The statistical significance is 12 σ for the Lexan data alone. The ME decrease is consistent with this. Between the two thin Lexan exposures in observation 1, about 8 hr apart, the average count rate dropped by 24%, significant at 4 σ. The ME was not

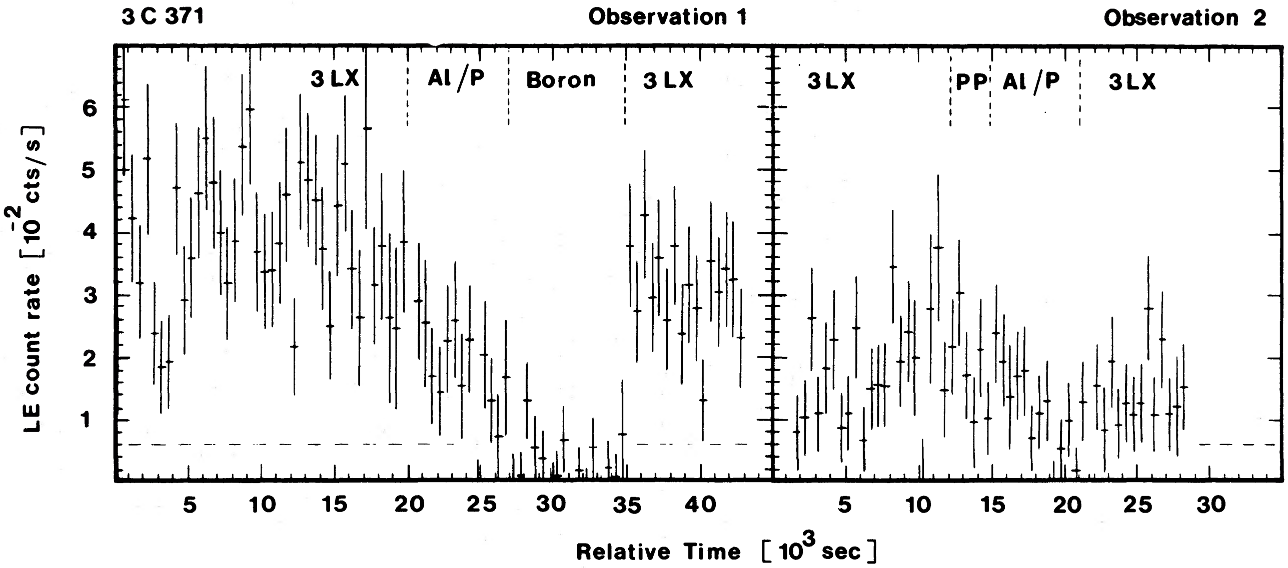

FIG. 3.—Background-corrected and deadtime-corrected LE count rates for 3C 371 in 500 s bins for both observations. The dashed horizontal line shows the level of the background count rate which has been subtracted. Variability is seen within the first thin Lexan (3LX) exposure, between the first and second thin Lexan exposures (average separation ≈ 8 hr), and between the second and third thin Lexan exposures (separation 18 days).

sensitive enough to see such a small change (the corresponding 4 σ sensitivity was 65%).

The count rate within the first thin Lexan exposure of observation 1 (0–20,000 s in Fig. 3) appears to be variable. A fit with a constant over this time leads to a reduced χ^2 of 1.45 for 38 degrees of freedom (d.o.f.), corresponding to 3% probability for randomness. In particular, during the first 6000 s, there seems to be a dip defined by three low points. A comparison of these points with four adjacent points on both sides yields a formal significance of 3.8 σ for a 50% depression lasting $\sim$25 minutes. The reduced χ^2 value for a fit to a constant over the same time interval is 2.17 for 11 d.o.f., corresponding to a probability of 1.5%. This probability has been verified by a Monte Carlo simulation. The "25 minute dip" could also be part of a larger event, e.g., of 75 minute duration with formal significance of 3.4 σ for 30% average depression.

It appears from Figure 3 that there may be linear variations in certain parts of the data. We have fitted constant and linear functions to various parts. The one short data segment for which a linear function is the better fit, to a significance level of 10%, is the first A1/P exposure with a slope of $\sim 2 \times 10^{-6}$ counts s^{-2} and duration of $\sim$7000 s. This time scale is roughly consistent (with a factor of 2) with the upper end of the "dip" time scale seen during the first thin Lexan exposure. The 24% drop established by comparing the average count rates from the first and second thin Lexan exposures could have happened entirely during the A1/P exposure.

V. COMPARISON WITH EARLIER X-RAY MEASUREMENTS

Previous evidence for X-ray variability in 3C 371 was presented by Snyder *et al.* (1982) from 80 days of monitoring with the *HEAO 1* Large Area Sky Survey (LASS) experiment, centered on 1977 September. The source changed by as much as a factor of 3 on time scales of 1–2 weeks. This is similar to our *EXOSAT* factor of 2.2 variability in 18 days. The *HEAO 1* A-2 detectors measured the source during part of the LASS exposure period (Marshall *et al.* 1979). We assume that the variable X-ray source within 1° of 3C 371 discovered by the *Einstein* IPC was giving negligible contribution to the *HEAO 1* flux densities, and that no other X-ray source contributed appreciably to the flux received within the 1°–3° collimators. Then, averaging the LASS intensity, we find that the two *HEAO 1* results combine to give an energy index for a single-component power law of $\alpha = 1.5 \pm 0.7$ between 2 and 6 keV, in agreement with our ME data. From the count rate given in the *HEAO 1* A-1 catalog (Wood *et al.* 1984) we estimate a flux density of 1.85 ± 0.25 μJy at 2 keV, while rates given in Snyder *et al.* (1982) lead to 1.4 μJy as a normal value and 2.3 μJy as a high value. The flux density we determine from the ME data of observation 1 is only 0.8 ± 0.2 μJy (68% error) at 2 keV, indicating variability of the medium energy X-rays between 1977 and 1984.

Worrall *et al.* (1984) report the two *Einstein Observatory* IPC observations of 3C 371, made in 1979 July and 1980 December. The 1 keV flux density was roughly the same for both observations but was several times lower than the extrapolated *HEAO 1* value and too weak for detection with the *Einstein Observatory* Monitor Proportional Counter. We have reanalyzed the IPC measurements, now that data from the revised processing system (Rev. 1B) are available. The useful exposure time in the 1979 July observation was only 1030 s (IPC observation 1). The 1980 December data were combined with data from 1981 February 1 to give 3265 s of useful data (IPC observation 2). The IPC energy range over which 3C 371 was detected is 0.1–3 keV. The data from each observation gives an acceptable fit to a single-component power law with absorption. However, we would not expect the data to be sensitive to a two-component power law, given the errors and the fact that the IPC energy range is smaller than that covered by the *EXOSAT* ME and LE combined data. The absorption is better constrained with the IPC than with the *EXOSAT* LE measurement; the longer IPC observation sets a 95% confidence upper limit of 10^{21} atoms cm^{-2}, implying an upper limit of 5.0×10^{20} atoms cm^{-2} for absorption intrinsic to 3C 371. When the total absorption is set at 5.0×10^{20} atoms cm^{-2}, the power-law fits and 95% errors are $\alpha = 1.6 \pm 0.7$ for IPC observation 1 and

$\alpha = 1.1 \pm 0.5$ for IPC observation 2. These indices agree better with those from the *EXOSAT* ME data than from the LE data, which would support the break in a two-component spectrum being below 1 keV.

Although the IPC spectral indices agree well with the *EXOSAT* ME index, the 1 keV flux densities do not. Since the response of the *EXOSAT* detectors is best below 1 keV for the LE and above 1 keV for the ME, the 1 keV flux density, 1.9 μJy, has a relatively large 90% uncertainty of 1.1 μJy. For N_H of 5.0×10^{20} atoms cm^{-2}, the 1 keV flux densities of IPC observation 1 and observation 2 were 0.43 ± 0.09 and 0.36 ± 0.07 μJy, respectively. Were we to use the maximum values of N_H allowed by the data, these 1 keV flux densities would only increase to about 0.6 and 0.5 μJy; still insufficient to agree with the *EXOSAT* or *HEAO 1* data. The long-term light curve of 3C 371 shows variability of as much as an order of magnitude.

VI. DISCUSSION

Our first result is the discovery with *EXOSAT* of X-ray variability in 3C 371 on several time scales: (*a*) $\sim$20–40 minutes, (*b*) 24% in $\sim$8 hr, and (*c*) a factor of 2.2 in 18 days. Comparing with earlier *HEAO 1* and *Einstein Observatory* measurements, we also find variability of up to an order of magnitude over a time scale of several years.

The variability on an $\sim$20–40 minute time scale agrees remarkably well with the prediction of Worrall *et al.* (1984) of variability on the time scale of 1 hr at 0.4 keV. This prediction resulted from a fit of multifrequency data to the Königl tapered jet SSC model. The fit required the relatively large value of 10 for the bulk relativistic Doppler factor, $\delta = 1/[\gamma(1 - \beta \cos \theta)]$ (θ is the angle to the line of sight of bulk motion of velocity βc, and γ is the Lorentz factor). The model fit assumed the condition $\sin \theta = 1/\gamma$, which maximizes the apparent superluminal velocity. Under this assumption, the superluminal angular velocity is predicted to be greater than 2.3 mas yr^{-1}. Radio observations now support superluminal motion in 3C 371 (Readhead, Pearson, and Unwin 1984; Pearson, Perley, and Readhead 1985), although quantitative results are not yet available.

If, instead, relativistic beaming does not apply to emission from 3C 371, and if the source is powered by a massive black hole, we can use light-travel time arguments to set a limit on the mass of the black hole, M. Assuming emission about 10 Schwarzschild radii from the hole, our $\sim$20–40 minute X-ray variability implies $M \lesssim 2 \times 10^7 M_\odot$. The multifrequency spectrum of the galaxy-subtracted emission from 3C 371 of Worrall *et al.* (1984) illustrates that most of the luminosity is in the optical band. An integration of the observed flux from 5×10^8 to 10^{18} Hz gives a luminosity of about 10^{45} ergs s^{-1} ($H_0 = 50$ km s^{-1} Mpc^{-1}; $q_0 = 0$). This is only a factor of a few less than the Eddington luminosity for a 2×10^7 $M_\odot$ black hole. However, if all the source emission is indeed beamed with $\delta = 10$, the actual source luminosity is reduced by δ^4 to only 10^{41} ergs s^{-1}, weaker even than most Seyfert galaxies. It may then be remarkable for such a relatively weak source to have such high bulk relativistic motion. More X-ray light curves and VLBI maps are needed to increase confidence in the value of δ.

Our second result is the measurement of the first X-ray spectrum of 3C 371. In the ME range, our spectrum is consistent with the spread of values found for other BL Lac objects (e.g., Worrall *et al.* 1981; Urry, Mushotzky, and Holt 1986). X-ray spectral breaks have been measured for some of the few brightest BL Lac objects (e.g., Worrall *et al.* 1981; Urry and Mushotzky 1982). These breaks are qualitatively similar to the likely break in 3C 371, but quantitatively the other objects have X-ray spectra which are overall somewhat flatter. For the other sources, it has generally been assumed that their softer spectrum is a continuation of a synchrotron spectrum which also dominates the optical continuum, whereas their flatter spectrum may be dominated by self-Compton emission. For 3C 371, our steeper low-energy X-ray component would not extend to meet the ultraviolet spectra of Worrall *et al.* (1984)—even the single power-law spectrum (H0 of § III) would extrapolate to a flux at 10^{15} Hz, an order of magnitude above that observed by *IUE*. However, the variability of 3C 371 suggests that comparison of noncontemporaneous data is dangerous, adding to the uncertainties in extrapolating over one to two decades of energy. We conclude that the possible curvature found in the X-ray spectrum may give qualitative support to an SSC model. Confirmation of the spectral curvature needs to be sought.

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