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Observations of X-ray spectra of two nearby QSO's: Mrk 205 and Mrk 1148

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Abstract. The 0.1 – 10 keV X-ray spectra of two nearby quasi-stellar objects (QSO's) known as Markarian 205 (Mrk 205) and Mrk 1148 (PG 0049 + 171), are presented based on observations with the *EXOSAT* Observatory. Simple power law models with the line of sight absorption consistent with the values obtained from the 21 cm surveys are sufficient to explain the observed spectra of both the X-ray sources. The energy index (α) for the X-ray spectrum of Mrk 205 is measured to be $0.96^{+0.08}_{-0.08}$. The value of α for Mrk 1148 is found to be $0.61^{+0.09}_{-0.10}$. These determinations assume that the column densities of equivalent hydrogen towards these sources are given by the accurate 21-cm measurements of Elvis et al. (1989). The present data do not require the presence of soft excess in these sources. There is no evidence for intrinsic absorption in these sources and no line features are detected in their X-ray spectra. The X-ray sources were found to be steady during the observations. The 2 – 10 keV X-ray luminosities of Mrk 205 and Mrk 1148 were $1.6\,10^{44}$ erg s^{-1} and $2.1\,10^{44}$ erg s^{-1} respectively.

Key words: quasars: individual – Mrk 205 – Mrk 1148 – PG 0049 + 171 – galaxies: nuclei of – X-rays: spectroscopy

1. Introduction

Studies of the X-ray spectra of quasi-stellar objects (QSO's) are useful for understanding the emission mechanisms in them and the properties of the environment surrounding these powerful radiators over the entire waveband from radio to X-rays. X-ray spectral observations of a variety of active galactic nuclei (AGN's) viz., quasars, Seyfert galaxies etc., were carried out with the *EXOSAT* observatory. Spectral results thus obtained from predominantly Seyfert type AGN have been presented by Turner & Pounds (1989); but observations of some of the quasars have not been analyzed or presented so far. We have been carrying out a detailed analysis of the X-ray spectral data obtained from the *EXOSAT* archives with the objective of studying the X-ray spectral features and their variations in relation to the intensity variations, if any, from some of these interesting objects, viz., PKS 1510 – 089 (Singh et al. 1990), PKS 2135 – 147 (Singh et al. 1991a) and PG 2130 + 099 (Singh et al. 1991b). Two of the QSO's observed with the *EXOSAT* are Markarian (Mrk) 205 at a redshift (z) of 0.07 (Weedman 1970) and Mrk 1148 (also known as PG 0049 + 171) at $z = 0.064$ (Schmidt & Green 1983). Although their X-ray spectra have been measured previously with the *Einstein* Observatory, because of the inherent variability of X-ray emission from such objects we have analyzed the *EXOSAT* archival data and report these measurements here for the first time.

Both the QSO's have fairly small redshift, and because of their proximity to us are amenable to detailed studies at all wavelengths. They are also both radio-quiet. The apparent visual magnitude of Mrk 205 is 15.24 (Véron-Cetty & Véron 1989), and it shows a weakly polarized component of 0.35% (Stockton et al. 1984). It is a source of near infra-red (0.3 μm–10 μm) emission (Neugebauer et al. 1979), weak radio emission ($\simeq 1$ mJy at 5 GHz) (Sulentic 1986), and X-ray emission (Tananbaum et al. 1979; Zamorani et al. 1981). The X-ray luminosity of this source shows a variability of $\sim 35\%$ on a time-scale of a few hours to a few days (Zamorani et al. 1984). X-ray spectral measurements based on the *Einstein* observations of Mrk 205 have been reported by Wilkes & Elvis (1987), Urry et al. (1989), Wilkes et al. (1989) and Kruper et al. (1990).

The apparent optical magnitude of Mrk 1148 is 15.88 in the blue band and its absolute blue magnitude is -22.07 (Schmidt & Green 1983). Its absolute magnitude is comparable to that of many bright Seyfert type I galaxies and indeed a galaxian fuzz has been reported around this object from high sensitivity CCD observations (Smith et al. 1986). Its infrared, optical and X-ray spectra have been studied by Elvis et al. (1986). The X-ray spectral energy index was measured by them to be $0.95^{+0.6}_{-0.4}$. This is consistent with both the mean energy index (1.05) of the PG QSO's studied by Elvis et al. (1986), as well as the standard Seyfert X-ray spectrum (Mushotzky 1984; Turner & Pounds 1989).

Here, we report the broad-band (0.1–10 keV) X-ray observations of these QSO's using the *EXOSAT*. The present observations provide accurate measurements of the spectral indices of Mrk 205 and Mrk 1148. The observations are described in Sect. 2. The analysis and results are given in Sect. 3, followed by a discussion in Sect. 4 where we compare our results with the previous measurements and also present the multi-wavelength spectra of these quasars.

2. Observations

2.1. Mrk 205

The X-ray emission from Mrk 205 was observed on 1983 November 10 and on 1984 January 27, using the low-energy (LE)

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telescope and the medium-energy (ME) detectors aboard the *EXOSAT* observatory. The details of the instruments used are given by de Korte et al. (1981) for the LE telescope, and by Turner et al. (1981) for the ME detectors. The particulars of the observations have been logged in Table 1. The low energy (<2 keV) data, during the two observations, were collected using the Lexan 3000 (LX3) filter placed in front of the Charge Multiplier Array (CMA) situated at the focus of the LE telescope. On the second occasion a second filter viz., aluminum/parylene (Al/P) was also used. The two filters have slightly different efficiency (cf. White & Peacock 1988). In the 1983 observation, the ME (1–10 keV) data were acquired with one half array of four argon filled detectors pointing at the source while the other similar half array monitored the background. The roles of the two arrays were exchanged midway through the observations, following the "swap" technique (Smith 1984). The 1984 observations with the ME were carried out using only half the array and the background was obtained while these detectors were slewing in and slewing out from the source position.

2.2. *Mrk 1148*

The X-ray emission from Mrk 1148 was observed on 1985 November 30 with the LE and the ME experiments aboard the *EXOSAT* observatory. The particulars of the observations are given in Table 1. The LE observations were carried out using both the LX3 as well as the Al/P filters. The ME data were acquired using the "swap" technique. Two of the detectors (viz., detectors number 3 and 6) were not operating during the observations, reducing the number of useful detectors in each array to three.

3. Analysis and results

The data were analyzed using the *XANADU* (X-ray Analysis and Data Utilization) software. The background subtracted source count rates in LE corrected for vignetting, telemetry dead time and the sum-signal distribution are listed in Table 1 for all the filters used. The background was obtained from regions surrounding and adjacent to the position of the source. We used the cell size of 128×128 arcsec^2 for source detection. The size was optimized after examining different box sizes. The background was determined from four times bigger area. The ME data were analyzed using the background obtained from the same detectors while offset. The count rates detected from the two sources in ME are given in Table 1, after correcting for vignetting and dead time. No short term variations on a time scale of 1000s were detected in either of the two objects.

We have examined each ME detector data individually for any systematics arising from the background subtraction. A simple power law was used and the resultant fit was examined visually and also the results were verified for an acceptable χ^2. Detectors which gave discrepant results or an unacceptably high χ^2 were rejected. In order to avoid systematic errors that may arise from combining the data, we have treated data from each detector separately and fitted them simultaneously. The data were grouped together for the plotting purpose only. This scheme also allows for application of corrections to the individual "inner" detectors (viz., numbers 2, 3, 6 and 7), which are prone to improper background subtraction during the swap (see Yaqoob et al. 1989).

The pulse-height (PH) information obtained from the LE and the ME detectors was analyzed for determining the spectral parameters of the X-ray emission. For the spectral fitting, the ME

Table 1. Log of *EXOSAT* observations and count rates for MRK 205 and MRK 1148

Detector combination	Start time (UT)	End time (UT)	Effective exposure time (s)	Count rate[a] (10^{-4} cm^{-2} s^{-1})
MRK 205 (1983 Nov 10)				
CMA+LX3	$18^h06^m16^s$	$20^h53^m12^s$	8391	2.80 ± 0.23
ME (Half 2)[b]	17 45 20	19 43 20	5762	5.90 ± 0.68
ME (Half 1)[c]	19 50 32	21 27 28	4542	6.50 ± 0.78
MRK 205 (1984 Jan 27/28)				
CMA+LX3	22 53 16	23 21 48	1685	2.60 ± 0.50
CMA+Al/P	23 43 16	01 13 33	5300	1.22 ± 0.22
ME (Half 2)	22 32 00	01 27 08	8939	5.80 ± 0.52
MRK 1148 (1985 Nov 30)				
CMA+LX3	13 02 42	15 00 50 }	19955	1.40 ± 0.13
CMA+LX3	16 17 54	20 30 34 }		
CMA+Al/P	15 04 26	16 14 42	3477	0.98 ± 0.28
ME (Half 2)[d]	12 36 50	16 32 34	9733	9.3 ± 0.6
ME (Half 1)[c]	16 42 42	20 36 42	11248	8.4 ± 0.6

[a] The count rates for the ME are for PHA channels 7 to 24 corresponding to the energy range of 1.5 to 6 keV with the best signal to noise ratio. The quoted errors are at 1σ level.
[b] Excluding detector number 7.
[c] Excluding detector number 3.
[d] Excluding detector number 6.

Table 2. Single power law fits for the *EXOSAT* ME data on Mrk 205 and MRK 1148

Date of observation	Energy index α	f(1 keV) (μJy)	Column Density N_H (10^{20} cm^{-2})	χ^2/dof
MRK 205				
1983 Nov 10	$0.74^{+1.56}_{-0.59}$	$1.3^{+13.0}_{-0.7}$	<401.0	131/134
	$0.73^{+0.46}_{-0.44}$	$1.3^{+0.9}_{-0.6}$	2.74[a]	131/135
1984 Jan 27	$1.12^{+1.24}_{-0.56}$	$1.9^{+10.7}_{-1.0}$	<294.6	85/100
	$1.13^{+0.47}_{-0.44}$	$2.0^{+1.3}_{-0.8}$	2.74[a]	85/101
Combined data	$0.94^{+0.92}_{-0.40}$	$1.6^{+5.0}_{-0.7}$	<222.0	217/236
	$0.95^{+0.32}_{-0.31}$	$1.7^{+0.7}_{-0.5}$	2.74[a]	218/237
MRK 1148				
1985 Nov 30	$0.53^{+0.60}_{-0.41}$	$1.4^{+2.1}_{-0.6}$	<153.0	105/100
	$0.54^{+0.32}_{-0.31}$	$1.4^{+0.7}_{-0.5}$	4.26[a]	105/101

Note: Quoted errors are at 90% confidence level.
[a] Fixed at the value determined from the 21 cm observations.

Table 3. Results of spectral analysis of *EXOSAT* LE+ME data on Mrk 205 and Mrk 1148
(a) Model: power law + line of sight absorption

Date of Observation	Energy index α	f(1 keV) (μJy)	Column density N_H (10^{20} cm^{-2})	χ^2/dof	Flux[a] 2–10 keV	0.1–2 keV
MRK 205						
1983 Nov 10	$0.73^{+0.62}_{-0.55}$	$1.33^{+1.42}_{-0.70}$	$1.33^{+5.2}_{-1.3}$	131/135	$7.2^{+1.0}_{-1.1}$	$7.3^{+0.8}_{-0.8}$
	$0.96^{+0.10}_{-0.10}$	$1.76^{+0.18}_{-0.19}$	2.74[b]	131.7/136	($7.3^{+1.0}_{-1.1}$	$12.4^{+1.3}_{-1.3}$)
1984 Jan 27	$0.94^{+0.74}_{-0.41}$	$1.54^{+1.44}_{-0.63}$	$2.84^{+13.7}_{-2.35}$	86.4/102	$6.6^{+0.8}_{-0.9}$	$6.3^{+1.0}_{-1.0}$
	$0.93^{+0.13}_{-0.13}$	$1.53^{+0.21}_{-0.22}$	2.74[b]	86.4/103	($6.6^{+0.8}_{-0.9}$	$10.5^{+2.0}_{-2.0}$)
Combined data	$0.80^{+0.31}_{-0.29}$	$1.37^{+0.69}_{-0.43}$	$1.65^{+2.7}_{-1.2}$	218.6/238	$6.8^{+0.6}_{-0.7}$	$6.9^{+0.6}_{-0.6}$
	$0.96^{+0.08}_{-0.08}$	$1.66^{+0.13}_{-0.13}$	2.74[b]	219.8/239	($6.9^{+0.7}_{-0.7}$	$11.7^{+1.1}_{-1.1}$)
MRK 1148						
1985 Nov 30	$0.54^{+0.43}_{-0.37}$	$1.42^{+1.03}_{-0.58}$	$3.42^{+7.5}_{-2.75}$	105/102	$11.0^{+0.9}_{-1.0}$	$5.5^{+0.6}_{-0.6}$
	$0.61^{+0.09}_{-0.10}$	$1.55^{+0.21}_{-0.21}$	4.26[b]	105.1/103	($11.1^{+0.9}_{-1.0}$	$8.7^{+1.1}_{-1.1}$)

(b) Model: broken Power law[c] + line of sight absorption[b]

	Energy index α_1	Energy index α_2	f(1 keV) (μJy)	χ^2/dof
MRK 205				
Combined data	$1.45^{+0.90}_{-1.35}$	$0.83^{+0.35}_{-0.35}$	$1.02^{+1.9}_{-0.7}$	219/238

Note: Quoted errors are at 90% confidence level.
[a] In units of 10^{-12} erg cm^{-2} s^{-1}. The values in bracket are those calculated without galactic absorption.
[b] Fixed at the value determined from the 21 cm observations.
[c] Break energy fixed at 0.6 keV.

channels 7 to 40 (corresponding to the energy range of 1.5 – 10 keV) are included. We used simple power law models along with absorption in the line of sight to the source to fit the data and the spectral fitting was carried out for ME data only and also for the LE and ME data taken together. The absorption cross-sections given by Morrison & McCammon (1983) were used. Using the χ^2 statistic we find that the simple model gives acceptable fits to data from both objects. The best fit spectral parameters obtained from this analysis along with their 90% confidence error bars estimated by keeping all the other interesting parameters free ($\chi^2_{min}+4.61$ for two free parameters) are listed in Table 2 (for ME data only) and Table 3 (for LE and ME combined fitting). Further details of the analysis and the results for the individual objects are given below.

3.1. Mrk 205

For the 1983 observation the ME data from the corner detectors (viz., numbers 1, 4, 5 and 8) were analyzed, as these were found to be most reliable and consistent. The 1984 data were obtained from three detectors only as one of the inner detectors (number 7) was noisier and inconsistent with the rest.

The energy index (α) for the X-ray spectrum of Mrk 205 is similar for the two cases, viz., ME only and LE and ME taken together (see Table 2 and Table 3). The parameters are better constrained when combined fit to the LE and ME data are performed. The value of α obtained from the above analysis is $0.73^{+0.62}_{-0.55}$ from the observation in 1983, and $0.94^{+0.74}_{-0.41}$ from the 1984 observation. The simultaneously estimated value for the column density, N_H, in the line of sight is consistent with the more accurately determined value of $2.74\,10^{20}\,\mathrm{cm}^{-2}$ from the 21 cm observations reported by Elvis et al. (1989). Keeping the N_H fixed at this value in our analysis resulted in a negligible change in the χ^2. This, however, allowed us to improve the accuracy of the spectral index measurement. The value of α from the two observations are now estimated to be 0.96 ± 0.10 and 0.93 ± 0.13, respectively. The X-ray flux (see Table 3) as well as the spectral index have remained steady during the two observations. We have, therefore, used all the available information from the two observations and simultaneously fitted data from all the good detectors (see above) to improve the accuracy of our measurements. The results from the analysis of all data are also listed in Table 3. The PH data obtained from all *EXOSAT* observations and the best fit power law spectrum are shown in Fig. 1, alongwith the residuals from such a fit. Taking the value of N_H as given by the 21 cm observations we obtain $\alpha=0.96\pm0.08$. The allowed values of α and N_H are shown in Fig. 2 for different levels of confidence. The contours plotted in Fig. 2 are for χ^2_{min} plus 2.71, 4.61 and 9.21 corresponding to confidence levels of 67%, 90% and 99% respectively, for two parameters of interest.

The present analysis does not, a priori, require a separate soft component or a low energy excess as observed in the X-ray spectra of some active galactic nuclei (AGN's). Recently, however, Wilkes et al. (1989) (see also Urry et al. 1989) report a low energy excess in Mrk 205 based on the analysis of *Einstein* observations using the imaging proportional counter (IPC) and the monitor proportional counter (MPC). We have also analyzed our data using broken power-law models as has been done by them and the results are given in Table 3(b). We assumed that the break energy is fixed at 0.6 keV, as found by Wilkes et al. (1989) for a bigger sample, and that the N_H is known from the 21 cm

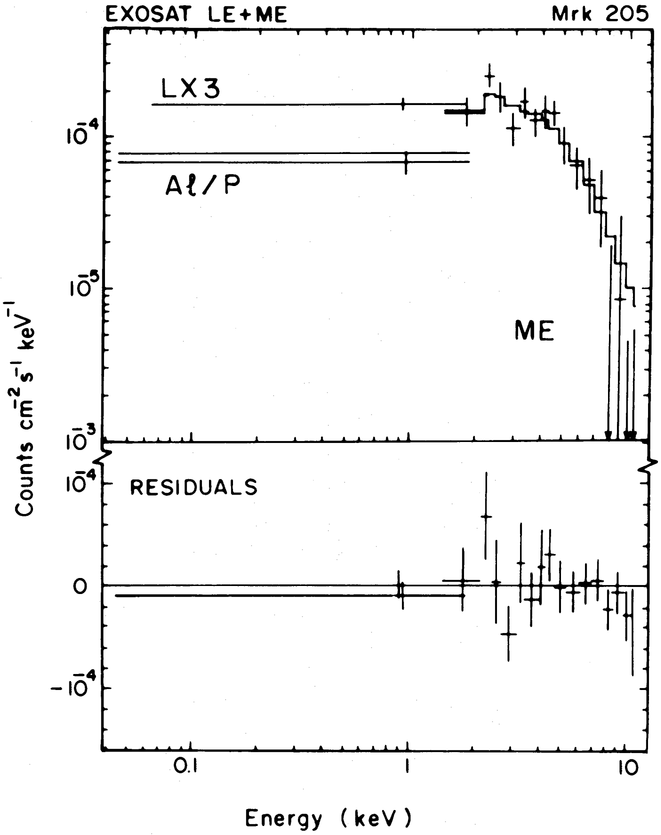

Fig. 1. The pulse-height (PH) data from observations of Mrk 205 with the LE and ME detectors of *EXOSAT* are shown. The two filters used for the LE observations are indicated. The data are from two observations separated by ~11 weeks. The histogram shows the predicted count distribution from the best fit single power-law model with an absorbing column in the line of sight. The lower panel shows the residuals between the data and the best fit spectral mode

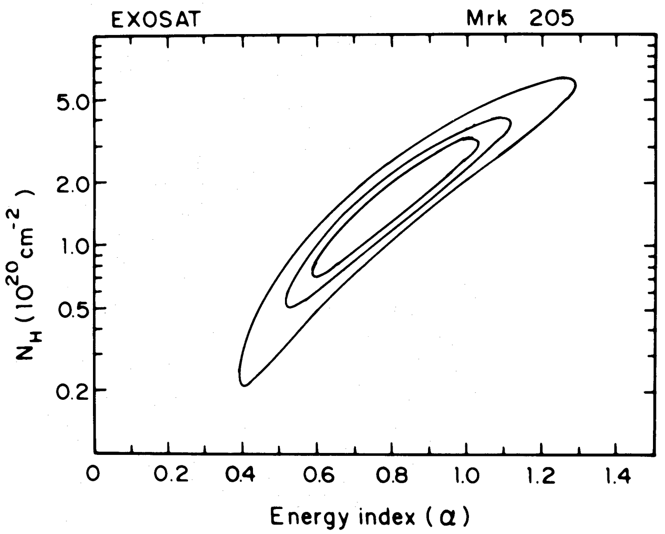

Fig. 2. Contour diagram of the allowed ranges for α and N_H for Mrk 205 for the combined data obtained on two observations separated by ~11 weeks. The three contours are for χ^2_{min} plus 2.71, 4.61 and 9.21 corresponding to confidence levels of 67%, 90% and 99% respectively, for two parameters of interest

observations. The present data is found to be equally well explained with such a broken power-law where the low-energy index $\alpha_1 \simeq 1.45$ and the high energy index $\alpha_2 = 0.83 \pm 0.35$. These results are very similar to that of Wilkes et al. Two component models of the type used by Urry et al. (1989) could not be constrained by the *EXOSAT* data.

3.2. *Mrk 1148*

The spectral data for this source were obtained from the detectors in the half 1 array only, as the detectors in the half 2 array were found to be very noisy (using χ^2 test described above) and therefore, unreliable. As for the source Mrk 205, the spectral parameters are better constrained when the LE and ME data are fitted together (see Table 2 and Table 3). The energy index (α) for the X-ray spectrum of Mrk 1148 obtained from the combined LE and ME fits is $0.54^{+0.43}_{-0.37}$. The estimated value for the column density, N_H, in the line of sight is consistent with the more accurately determined value of $4.26\,10^{20}\,\mathrm{cm}^{-2}$ from the 21 cm observations reported by Elvis et al. (1989). The PH data and the best fit power law spectrum are shown in Fig. 3, alongwith the residuals from such a fit. Keeping the N_H fixed at this value in our analysis did not result in any change in the χ^2. With the N_H thus fixed, the estimated value for α is $0.61^{+0.09}_{-0.10}$. The previously obtained value for α by Elvis et al. (1986) is not inconsistent with this considering their error bars. The allowed values of α and N_H are shown in Fig. 4 for different levels of confidence. The contours plotted in Fig. 4 are for χ^2_{min} plus 2.71, 4.61 and 9.21 corresponding to confidence levels of 67%, 90% and 99% respectively, for two parameters of interest.

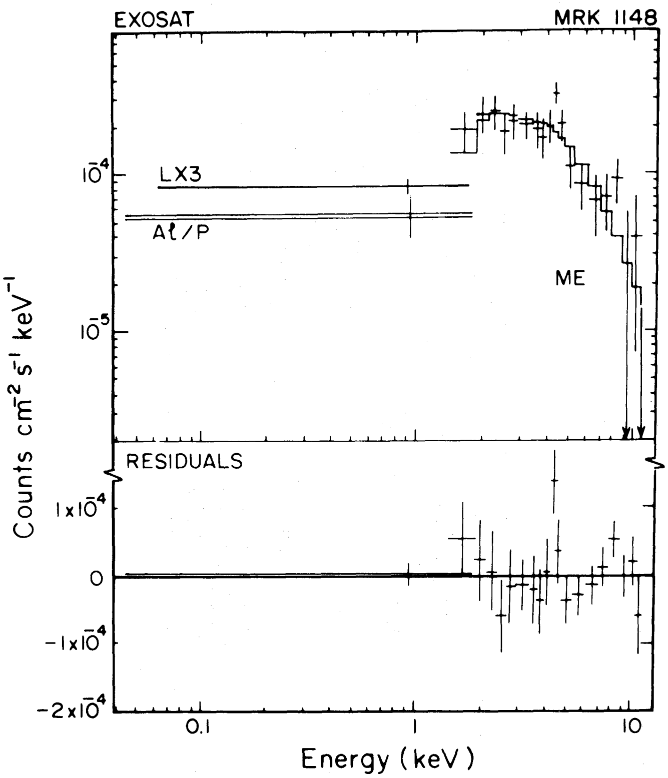

Fig. 3. Same as in Fig. 1, but for *EXOSAT* observations of Mrk 1148 on 1985 November 30

The present data do not require a separate soft component or a low energy excess in Mrk 1148. A broken power-law, as described above, when fitted to the data, was equally acceptable but could not be meaningfully constrained by the present data.

4. Discussion

The X-ray luminosities, as observed in the 2–10 keV energy band, are found to be $1.6\,10^{44}\,\mathrm{erg\,s^{-1}}$ and $2.1\,10^{44}\,\mathrm{erg\,s^{-1}}$ for Mrk 205 and Mrk 1148, respectively. We assume a value of $50\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ for the Hubble constant and $q_0 = 0$ in the Friedmann Cosmology. The only previously reported measurements of these objects in a similar energy band are based on the *HEAO A2* observations in 1977 and 1978 (Della Ceca et al. 1990). The values derived from the 2–10 keV count rates reported by them are in agreement with our measurements. We assumed an energy index of 1.0 for the conversion of the count rates observed from 1977 October 28 observation of Mrk 205, and an energy index of 0.65 for a similar conversion in the case of Mrk 1148 that was observed on 1978 January 9.

4.1. *Comparison with the Einstein observations*

4.1.1. Mrk 205

The average X-ray flux at 1 keV observed with the *EXOSAT* in 1983–84 is 1.66 ± 0.13 µJy, which is ~23% lower than the flux observed in 1980 with the *Einstein* (Wilkes & Elvis 1987). A comparison with the results of Kruper et al. (1990) using the bandwidth of 0.2–4.0 keV confirms this result. The unabsorbed luminosity measured by us in the 0.2–4.0 keV bandwidth is $2.7\,10^{44}\,\mathrm{erg\,s^{-1}}$. No significant short term variability over a time scale of a few thousand seconds or one year is detected.

The spectral index reported by Wilkes & Elvis (1987) from the *Einstein* observation in 1980, was $\alpha = 0.80 \pm 0.20$ over the energy range of 0.3–3.5 keV, with the line of sight absorption being a

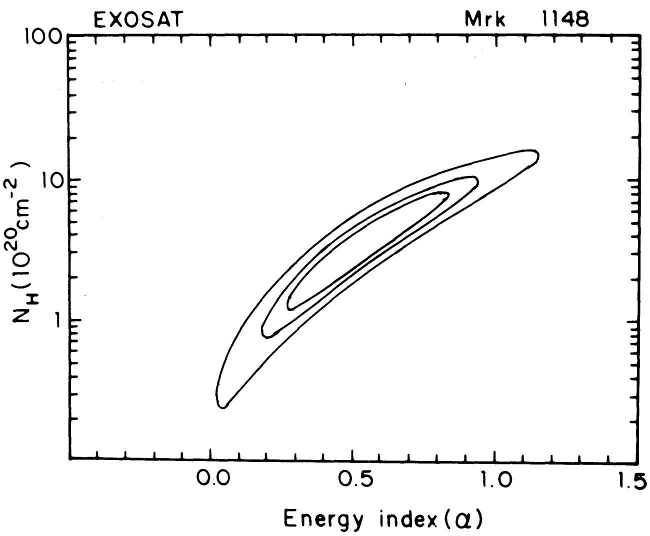

Fig. 4. Contour diagram of the allowed ranges of α and N_H for observations of Mrk 1148 on 1985 November 30. The confidence levels associated with the contours are the same as in Fig. 2

free parameter in their spectral modeling. A re-analysis of the IPC data reported by Kruper et al. (1990) finds $\alpha=0.84^{+0.07}_{-0.05}$. These are in agreement with the result obtained by us using the same fitting procedure, viz., $\alpha=0.80^{+0.31}_{-0.29}$. When the N_H is fixed to the Galactic value, however, the α is estimated to be $0.95^{+0.02}_{-0.01}$ by Kruper et al. (1990) and $0.96^{+0.08}_{-0.08}$ by us, which are also in close agreement. Urry et al. (1989) and Wilkes et al. (1989) have recently re-analyzed the IPC and the MPC data thus extending the total bandwidth to higher energies, and using the accurate values for the line of sight Galactic absorption. Using a single power law model, Urry et al. report an $\alpha=0.94$. They also report a marginal indication for the presence of a very soft excess. According to Wilkes et al. (1989), however, the combined IPC/MPC X-ray spectrum shows a definite soft excess with $\alpha_{\rm HE}=0.85$ and $\alpha_{\rm LE}=1.4$. Our results from fitting a broken power law (see Table 3) are in excellent agreement with the above values reported by Wilkes et al. (1989) using the same spectral model. Wilkes & Elvis (1987) had also tried to study the complexity of the spectral shape by analyzing only the 0.6 – 3.5 keV data from the IPC and found $\alpha=0.9\pm0.1$, which is not inconsistent with the present results. A broken power law indicates a steeper slope for very low energies (below 0.6 keV) and a somewhat flatter slope for the higher energies. The higher energy slope thus determined is consistent with the canonical Seyfert spectrum (Mushotzky 1984; Turner & Pounds 1989). This suggests that the characterization of the overall X-ray spectrum by a single power law could lead to a steeper slope due to the presence of a softer component which cannot be ruled out from the present observations, and which has been shown to exist in Mrk 205 by Wilkes et al. (1989) from the *Einstein* observation. Such a possibility was noted by Elvis et al. (1986), though they preferred a single steep slope as an explanation. For the radio-quiet objects like Mrk 205, the energy slopes estimated by Elvis et al. (1986) using a single power-law model were generally steeper than the canonical value.

The present observations, therefore, indicate no spectral change in Mrk 205 over a time-scale of a few years although a small intensity change is noticeable.

4.1.2. Mrk 1148

The X-ray flux measured from the source in the 0.3 – 3.5 keV energy range by Elvis et al. (1986) is $14.3^{+4.6}_{-2.7}\ 10^{-12}$ erg cm^{-2} s^{-1}, after correcting for the Galactic absorption. The X-ray flux measured with the *EXOSAT* in the same energy band is 9.65 $\pm 1.2\ 10^{-12}$ erg cm^{-2} s^{-1}. Considering the systematic uncertainties in the two measurements, the difference may not be very significant.

The X-ray spectrum of Mrk 1148 is almost indistinguishable from that of the well studied Seyfert galaxies (Mushotzky 1984; Turner & Pounds 1989). Assuming that the absorption in the line of sight to Mrk 1148 is well known from the 21 cm observations, the present observations do not require a steeper spectrum as has been suggested from the study of a sample of PG quasars by Elvis et al. (1986).

4.2. *Radio to X-ray quasar energy distribution*

In Figs. 5 and 6, we have plotted the overall rest-frame energy distributions of Mrk 205 and Mrk 1148, respectively, using the multiwavelength observations reported in the literature and the X-ray spectra presented here. The measurements of the radio flux from Mrk 205 are from Mazzarella & Balzano (1986) for 1.4 GHz, and Sulentic (1986) and Feigelson (private communication) for 5 GHz. The mm observations of Mrk 205 have been reported by Ennis et al. (1982) and the far-infra red fluxes have been taken from the *IRAS* Catalogue of Galaxies and Quasars (Joint IRAS Science Working Group 1985). The *IRAS* detected a strong 100 µm flux from Mrk 205 failing, however, to detect any flux at shorter wavelengths for which we have plotted only the upper limits. The 0.3 to 10 µm fluxes have been taken from Neugebauer et al. (1979). The overall energy distribution in this quasar is very unusual principally due to the big-bump in the far infrared, which may signify the presence of a large amount of dust in the quasar. The optical and X-ray fluxes appear to lie on a straight line with a small bump near the ultraviolet which might

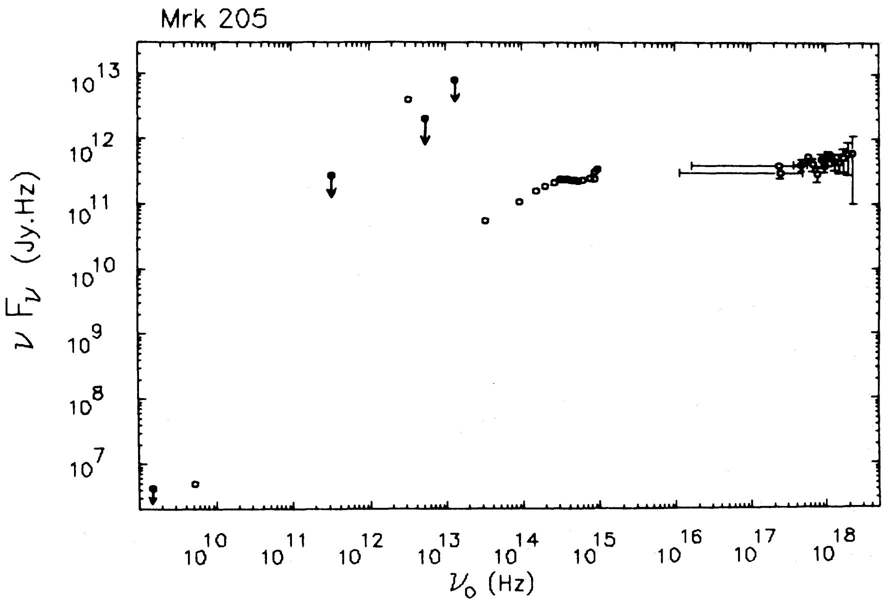

Fig. 5. Multi-wavelength energy spectrum of Mrk 205 plotted in the rest frame of the quasar

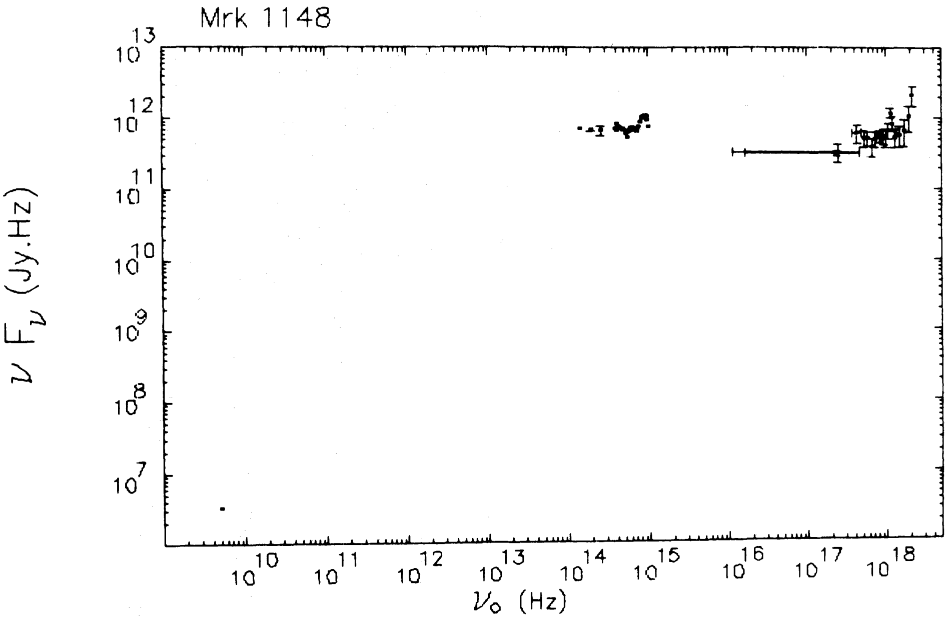

Fig. 6. Multi-wavelength energy spectrum of Mrk 1148 plotted in the rest frame of the quasar

extend into soft X-rays. Such shapes can be synthesized from accretion disk models and non-thermal emission as shown by Band & Malkan (1989).

Radio measurements of Mrk 1148 have recently been reported by Kellerman et al. (1989). A peak flux of 0.66 mJy at 5 GHz, as measured by them, has been plotted in Fig. 6. There are no far infrared measurements reported for Mrk 1148. The optical and infra-red measurements are taken from Elvis et al. (1986) and plotted along with X-ray measurement reported here, thereby extending the X-ray energy bandwidth somewhat compared to that in Elvis et al. (1986). The overall distribution is typical of the radio-quiet quasars (see Sanders et al. 1989). A small bump is visible in the near ultraviolet. The extrapolated infra-red flux is consistent with the medium energy X-ray flux though lying above the soft X-ray flux. A small rise in the X-ray flux with energy is indicated in this radio-quiet quasar. Such a trend is normally found in the radio-loud quasars (Wilkes & Elvis 1987). Far infrared and mm measurements of Mrk 1148 are needed to fully understand its full energy spectrum.

In conclusion, the present observations provide a fairly accurate measure of the X-ray spectra of two radio-quiet quasars. More sensitive observations with broad-band X-ray detectors would be extremely useful for a clearer understanding of the spectral properties of these QSO's.

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