Multi-wavelength Observations of 3C 273 in 1993-1995

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We present the results of the multi-wavelength campaigns on 3C 273 in 1993-1995. During the observations in late 1993 this quasar showed an increase of its flux for energies $\geq 100$ MeV from about $2.1 \times 10^{-7}$ photons cm$^{-2}$s$^{-1}$ to approximately $5.6 \times 10^{-7}$ photons cm$^{-2}$s$^{-1}$ during a radio outburst at 14.5, 22 and 37 GHz. However, no one-to-one correlation of the $\gamma$-ray radiation with any frequency could be found. The photon spectral index of the high energy spectrum changed from $\Gamma_\gamma = (3.20 \pm 0.54)$ to $\Gamma_\gamma = (2.20 \pm 0.22)$ in the sense that the spectrum flattened when the $\gamma$-ray flux increased. Fits of the three most prominent models (synchrotron self-Comptonization, external inverse Comptonization and the proton initiated cascade model) for the explanation of the high $\gamma$-ray emission of active galactic nuclei were performed to the multi-wavelength spectrum of 3C 273. All three models are able to represent the basic features of the multi-wavelength spectrum. Although there are some differences the data are still not decisive enough to discriminate between the models.

1. Introduction

The identification of 54 EGRET $\gamma$-ray sources with radio-loud active galactic nuclei (AGN) (Thompson et al. 1993, 1996) has drawn the attention of the astronomical community to these very interesting extragalactic objects. The observations have shown
that for all AGN detected by EGRET the energy output in the high energy regime is at least as high as, and during active periods can be as much as 10-30 times, that in the optical regime. An extensive summary of the results from phases 1 and 2 (1991 May 16 to 1993 August 17) of the observations of these AGNs with EGRET and their implications has been given by von Montigny et al. (1995).

3C 273 shows all the characteristics which are typical for high luminosity quasars: a flat radio spectrum of the core, strong and rapid variability in the optical and other energy ranges (Courvoisier et al. 1988, Courvoisier et al. 1990), variable polarization, a radio jet with superluminal motion. Additionally, it shows an optical and X-ray jet and a very prominent UV excess, the so-called “big blue bump”. Although 3C 273 is not a high polarization quasar (HPQ) — for which the standard definition is that the optical polarization exceeds 3% at least once — it is an interesting borderline case between high and low polarization quasars (LPQs). Sometimes it is dubbed a ‘miniblazar’ since it shows polarization flares similar to the true HPQs, but only up to the 1% level, and almost hidden by the non-polarized flux variations (Impey et al. 1989, Valtaoja et al. 1990, Valtaoja et al. 1991).

It is one of the best studied quasars and has been detected and observed in every energy band from radio to γ-rays. It was first detected as a very bright radio double source (Schmidt 1963). Component A of the double source was identified with the optical quasar (Schmidt 1963, Conway et al. 1982) and has a very flat radio spectrum \( S \sim \nu^{\alpha_r} \) with a spectral index \( \alpha_r \approx -0.01 \) \( \pm 0.07 \) between 2.7 and 5 GHz (Kühr et al. 1981). Component B is associated with an optical jet and its radio spectral index is much steeper: \( \alpha_r \approx -0.7 \). Its apparent magnitude in the optical is \( m_v = 12.5 \) mag. The optical jet is one-sided and faint.

3C 273 was first identified as an X-ray source by Bowyer et al. (1970). Its luminosity in the 2 - 10 keV band is \( \sim 10^{46} \) erg/s and the X-ray spectral index in this energy band varies in the range \(-0.25 \leq \alpha_x \leq -0.5\) (Courvoisier et al. 1987). An X-ray feature coinciding with one of the enhancements in the optical jet was discovered by the EINSTEIN-HRI (Harris & Stern 1987). Two detections of a high energy γ-ray source in the Virgo region were reported with the COS-B satellite in 1976 and 1978. This γ-ray source was identified with 3C 273 because of the positional coincidence (Swanenburg et al. 1978, Bignami et al. 1981).

During the all-sky survey of the Compton observatory in Phase 1 (1991 May to 1992 November), 3C 273 was detected by all four instruments aboard the observatory (BATSE: Paciesas et al. 1994; OSSE: McNaron-Brown et al. 1994; COMPTEL: Hermsen et al. 1993, Williams et al. 1993; EGRET: von Montigny et al. 1993). The main result from Phase 1 is the presence of another maximum in the energy output in the 1-10 MeV range.
of the electromagnetic spectrum which is about as high as the maximum of the UV-Bump (Lichti et al. 1994, 1995).

Because 3C 273 is such a well-studied, bright object from radio through X-rays it seems to be well suited for detailed studies in order to learn more about the physical processes taking place in quasars. Intensive studies of the variability have already been performed in order to look for correlations between different energy bands (Courvoisier et al. 1987, Robson et al. 1993). These studies found correlations between the infra-red (1.25μm(J); 1.65μm(H); 2.2μm(K); 3.8μm(L′); 800μm) and shortest radio wavelengths (1.1 mm and 3.3 mm). However, these correlations were not seen for every flare but only in some (Robson et al. 1993).

Since those studies did not include the high energy γ-ray range, an international campaign was organized to observe 3C 273 simultaneously at all wavelengths from radio through MeV and TeV γ-ray energies during Phase 3 (1993 August 17 to 1994 October 3) and Cycle 4 (1994 October 4 to 1995 October 3) of the Compton Observatory mission, in the hope that it would be possible to discriminate between the various models which have been developed in order to explain the γ-ray emission from blazars: (i) the synchrotron self-Compton (SSC) model (e.g. Maraschi, Ghisellini, & Celotti 1992, Bloom & Marscher 1992, 1993); (ii) the inverse Compton process on external photons (EC-models) which could be either photons from the accretion disk (Dermer, Schlickeiser, & Mastichiadis 1992) or reprocessed photons from the broad-line region (Sikora, Begelman, & Rees 1994, Dondi & Ghisellini 1995), or (iii) synchrotron emission from ultra-relativistic electrons and positrons produced in a proton-induced cascade (Mannheim & Biermann 1992, Mannheim 1993a).

We are aware that there are even more models. But we can not consider all these models here since it would go beyond the scope of this paper which is mainly to present the data from the multiwavelength campaign. Hence, we concentrate only on the three basic models. For an overview of models see e.g. von Montigny et al. (1995) and references therein.

In this paper we describe observations of 3C 273 with EGRET during Phases 2, 3 and Cycle 4 of the Compton observatory mission (§2) as well as simultaneous or quasi-simultaneous observations across the entire electromagnetic spectrum during Phase 3 (§3). The results are given in §4. In §5 we present a discussion of the results.

2. EGRET observations and analysis

A detailed description of the EGRET instrument is given by Kanbach et al. (1988). The instrument calibration, both before and after launch, is presented by Thompson et al.
The analysis of the EGRET data (Fichtel et al. 1994) used counts and exposure maps for photon energies for different energy intervals as well as the diffuse γ-ray background predicted by the standard EGRET analysis software from HI and CO distributions (Bertsch et al. 1993, Hunter et al. 1996). The maps containing all events with energies ≥ 100 MeV were used for the detection and determination of the position of the source in order to avoid the rather broad point spread function (≥ 5°) below 100 MeV. For the determination of the spectrum of the source, the maps containing 10 standard energy intervals were used.

This analysis used a maximum likelihood method which simultaneously gives the best fit of the diffuse background to the data (Mattox et al. 1996). Prominent EGRET sources other than 3C 273 in the viewing period under consideration were added iteratively to the diffuse background model. Throughout the analysis a photon spectrum power law index of Γ = 2.0 was assumed for the spectra of the sources which is a typical spectral index for the strong EGRET blazars (von Montigny et al. 1995, Chiang et al. 1995). The formal significance of a source detection in standard deviations is determined from the square root of the likelihood test statistic TS (Eadie et al. 1971, Mattox et al. 1996) which is given by two times the natural logarithm of the ratio of the maximum likelihood values for the alternative and the null-hypothesis.

### 2.1. Time variability

Table 1 lists the observations, the fluxes and significances from the EGRET observations in phases 1, 2, 3 and cycle 4. When the source has TS < 9 (corresponding to a formal significance of < 3σ) it is regarded as not detected and 2σ upper limits are given.

After the initial detection of 3C 273 by EGRET in 1991 June (viewing period (VP) 3) in phase 1 (von Montigny et al. 1993) its flux (always for energies ≥ 100 MeV) had decreased in strength during later observations in 1991 October (VP 11) and in 1992 December through 1993 January (VP 204 through 206) in phase 1 and 2 (von Montigny et al. 1993, Sreekumar et al. 1996); only upper limits could be derived (see also Table 1 and Fig. 3, bottom panel). Then in phase 3 during 1993 October to 1993 December (VP’s 304 - 308.6) and 1993 mid-December to 1994 January (VP’s 311 - 313) the flux of 3C 273 increased from about 2.1·10⁻⁷ photons cm⁻² s⁻¹ to approximately 5.6·10⁻⁷ photons cm⁻² s⁻¹ between 1993 October 19 and 1993 December 1 (VP’s 304 through 308.6). This is an increase by about a factor of 3 within 43 days (Fig. 3, bottom panel) and it is the only time so far that EGRET has seen 3C 273 to be at about the same flux level (6.0·10⁻⁷ photons cm⁻² s⁻¹) as
during the COS-B observations (Swanenburg et al. 1978, Hermsen et al. 1981). Fourteen days later, and again in Cycle 4 (1994 November 21 through 1995 January 3) it returned to a quiet state.

### 2.2. Spectrum

We derived spectra from each viewing period and sums of viewing periods in which 3C 273 was detected with a significance greater than 3$\sigma$. In order to determine the spectra the estimated number of source counts in ten observed energy intervals was determined by a likelihood analysis (Mattox et al. 1996).

The simplest spectral model that adequately fit the data was a power law of the form

$$dN/dE = N_o (E/E_o)^{-\Gamma_\gamma}$$

where $E_o$ is the energy scale factor chosen so that the statistical errors in the power law index, $\Gamma_\gamma$, and the overall normalization, $N_o$, are uncorrelated.

The values of the parameters $N_o$, $\Gamma_\gamma$ and $E_o$ are given in Table 2 for the different observations. The gamma-ray photon spectral index was found to vary from viewing period to viewing period from $\Gamma_\gamma = (3.20 \pm 0.54)$ to $\Gamma_\gamma = (2.20 \pm 0.22)$. The errors are determined from $\Delta \chi^2 = 1$ (see Dingus et al. 1996).

Figure 1 compares the spectra from 3C 273 during VP 305 and VP 308.6 with each other. These are the observations where 3C 273 had the lowest and the highest flux in phase 3, respectively. It can be seen that the increase in flux results from the hardening and pivoting of the spectrum around the low energy end.

There appears to be a correlation between the spectral index and the integral flux above 100 MeV in phase 3 (Fig. 2). The linear correlation coefficient between these two variables is -0.91, and the significance level at which the null hypothesis of zero correlation is disproved is 1.1%. However, if one includes the data from VP 3 and COS-B, the linear correlation coefficient changes to about -0.72, corresponding to a probability that this set of data was drawn from a uniform distribution of about 4.3%. The significance of the correlation is not very high since the errors on both variables are rather large. Since this correlation is not yet compelling we will use the average EGRET spectrum derived from the sum of the viewing periods 304 through 308.6 for the rest of the paper. Nevertheless, there is evidence that the $\gamma$-ray spectra harden when the source flux increases. There are indications for this behaviour not only from 3C 273 but also from other $\gamma$-ray sources. Mücke et al. (1996a) did a statistical analysis of this relation with all EGRET sources for
which spectra and fluxes were available (e.g. 0528+134, Mukherjee et al. 1996; 1222+216, Sreekumar et al. 1996; 3C 279, Kniffen et al. 1993). They also find that the average source appears to have a harder spectrum at high γ-ray states. The chance probability is of the order of $10^{-5}$.

3. Multiwavelength observations

Soon after the discovery of the June 1991 flare in 3C 279 and the realization that most of the γ-ray blazars are highly time variable, it was recognized that simultaneous observations of these sources across the entire electromagnetic spectrum are of crucial importance for the understanding of their emissions. This led to an international campaign to observe 3C 273 simultaneously at as many wavelengths as possible in 1993 and 1994. The following section reports on the results of these observations.

3.1. Radio

Reich et al. (1993) have already described the multifrequency observing method used at the Effelsberg 100-m telescope to monitor variable sources as detected by EGRET. The observations result in quasi-simultaneous flux density measurements at 2.7 GHz, 5 GHz and 10.7 GHz.

Observations at 22 and 37 GHz were made at the Metsähovi Radio Research Station. The observing procedures are described in detail in Teräsranta et al. (1992). The data presented here are weekly mean values.

Observations were also made with the University of Michigan’s 26-meter telescope at 4.8, 8.0 and 14.5 GHz. A description of the data reduction is given in Aller et al. (1985). The fluxes are daily averages. Table 3(a-f) lists the radio data used here.

3.2. Millimeter and sub-millimeter

The 3 mm and 1.3 mm (90 GHz and 230 GHz, respectively) observations were made with the Swedish-ESO Submillimetre Telescope (SEST) at the European Southern Observatory site of Cerro La Silla, Chile.

For the 3 mm observations a dual polarisation Schottky receiver in a double sideband mode was used. For the 1.3 mm observations a Schottky receiver and a wide band
acousto-optic spectrometer were used initially, but later a single channel bolometer was used for most of the sessions. The bolometer had a bandwidth of about 50 GHz, centered at 236 GHz. To convert the intensities into flux densities, the measurements were calibrated against planets, with 3C 274 as a secondary calibrator \cite{Tornikoski1996}.

Data were also obtained at wavelengths of 450, 800, 1100, 1300 and 2000 microns using the JCMT at Mauna Kea \cite{Duncan1990}. Tables 4(a-f) summarize the results from the observations in the mm- and sub-mm wavebands.

### 3.3. IR and optical

Observations have been carried out in UBVRIJHK with sparse sampling at the Swiss 0.7m telescope on La Silla, the 0.7m telescope in Heidelberg and with UKIRT in Hawaii using standard CCD detectors and a NICMOS 3 array camera. The data are shown in Table 5. Observational procedures and data calibration has been carried out as described in Courvoisier et al. (1987).

### 3.4. UV/EUV

3C 273 is observable by IUE only during the time intervals mid-December – mid-February and May – mid-June. There were observations of 3C 273 with IUE on 1993 January 8 (2 SWP respectively 3 LWP spectra coadded) and 1994 June 20 (4 SWP, 4 LWP) as well as from 1995 January 3 to 12 (20 SWP, 21 LWP). The average exposure for SWP spectra was \( \sim 30 \) minutes and for LWP spectra \( \sim 25 \) minutes.

We have also obtained EUVE coverage of 3C 273 with the EUVE Deep Survey/Spectrometer during the 1994 January 8 to 14 (modified julian dates: 49360 - 49366) time frame for a total of 205,219 s (effective exposure time: 130,093 s). The total photometric flux in the range 67 – 178 Å was \((7.2 \pm 0.081) \times 10^{-2}\) counts/s. For details about the analysis see Ramos et al. (1996).

Table 6 lists the results of these observations. A reddening correction for interstellar absorption of E(B-V) = 0.03 has been applied to the values from the reddening law of Seaton (1979). The errors in fluxes are obtained by also taking into account the calibration error of IUE (\( \sim 5\text{-}10\% \)).
3.5. X-rays

ASCA observed 3C 273 for calibration purposes on five different occasions namely on 1993 December 16, 19, 20, 23 and 27. Assuming a single power law with the Galactic absorption ($N_H = 1.8 \cdot 10^{20}$ H-atoms/cm$^2$) in the 0.5-10 keV range a spectrum for 3C 273 could be derived from these measurements. Details of the ASCA instrument and its calibration are given in Makishima et al. (1996) and references therein. Table 7 contains the results which were obtained using the 1994 versions of the instrumental response and efficiency functions for the analysis.

3.6. High energy observations

The OSSE instrument is sensitive to $\gamma$-rays in the 0.05 – 10 MeV range. It consists of four identical but independently positionable detector systems providing an orientation range of 192°. For details about the instrument and analysis procedures, see e.g. Johnson et al. (1993, 1995). OSSE observed 3C 273 simultaneously with COMPTEL and EGRET only for 7 days from 1993 December 20 to 27 (VP 312). The results from these observations are given in Table 8.

The COMPTEL energy range (0.75 – 30 MeV) overlaps with the OSSE energy range. Detailed descriptions of the instrument can be found in Schönhfelder et al. (1993). COMPTEL has also detected 3C 273 and Table 9 gives the fluxes derived by a maximum likelihood method (for its application to COMPTEL data see de Boer et al. 1992). The spectrum obtained is the average over two distinct time periods: 1993 October 19 to December 1 and 1993 December 13 to 1994 January 3 (VP’s 304 – 313).

The Whipple Telescope observed 3C 273 during several epochs. The observation closest in time to the EGRET observations is from 1994 March. 3C 273 was not detected during that observation. Therefore, only an upper limit could be provided. For energies $\geq$ 0.3 TeV the flux limit was $< 1.7 \cdot 10^{-11}$photons cm$^{-2}$s$^{-1}$. Assuming an $E^{-2}$ power law this flux value corresponds to a flux density $F_\nu < 1.1 \cdot 10^{-2}$pJy.

4. Results
4.1. Multifrequency Variability

In the case of 3C 273 it seems that the gamma radiation is possibly related to the slower radio outbursts at 14.5, 22 and 37 GHz. There are two slower outbursts at 22 and 37 GHz, the first peaking around 1991.67 (MJD ∼ 48470) and the second around 1993.96 (MJD ∼ 49330). The second outburst peaks first at 37 GHz then at 22 GHz and finally at 14.5 GHz. The second outburst does not look as impressive because it is buried within the decline of the very strong first outburst; nevertheless it still represents a major radio burst. All the detections of 3C 273 with EGRET occurred during the rising parts or at the maxima of the major, slower radio outbursts. Most of the non-detections were during the declining part of these burst components or during a very early stage of the outburst (Fig. 3, 2nd and 4th panels).

The $\gamma$-emission disappeared during 1993 December. This seems to occur just after the second radio burst component is peaking. According to Valtaoja & Teräsranta (1995) EGRET detections occur in general during the rising part of the 22 and 37 GHz radio flare, and once the radio reaches its peak, the gamma radiation ceases.

While it is fair to say that the gamma-ray-bright phase coincides temporally with radio activity, there is no way to prove or disprove the hypothesis of ‘related’ activity on the basis of the data shown here. Statistically there appears to be good evidence that gamma-ray detections occur during radio outburst rises, but with the undersampling of the gamma-ray data one cannot make claims for correlated gamma-radio activity. The entire period discussed here corresponds to a general decline at cm-wavelengths on which some more rapid fluctuations are superposed. Also, note that while 3C 273 is very bright at radio wavelengths, in the gamma-ray region it has been only moderately strong during detections; there is no clear correlation between gamma-ray flux and radio-flux in general.

It is interesting to note that the intensity of 3C 273 appears to have gone through a local, very flat minimum for wavelengths ≤ 1.3mm (Fig. 3, 3rd panel) during the observed increase at 14.5, 22 and 37 GHz and in $\gamma$-rays. A $\chi^2$ test shows that the spread in the sub-mm fluxes in the time range MJD 49300 − 49400 is consistent with constant fluxes even for the 1.1 mm data (Fig. 4). However, the period just before and during the first part of the gamma outburst was not observed because of sun constraints.

In the IR/optical no significant variations have been recorded within the poor sampling throughout the entire period. The range of variations found by Courvoisier et al. (1987) in the optical/IR range was larger, but the average values are compatible. Likewise, the near-IR and optical continuum slopes (as measured by nearly simultaneous JHK, UBV or BVRI sequences) remained constant throughout the period and comparable to the
average slopes. During several epochs with non-photometric conditions variations on short
time-scales were searched for by differential photometry (comparing fluxes to constant stars
within the same frames). These data had a sampling of about 1 hour$^{-1}$. They are not flux
calibrated and not listed in Table 5. No indications for rapid variations in V and R were
found to a level of 1.2 %.

4.2. Multifrequency Spectrum

Unfortunately, not all of the multiwavelength observations were truly simultaneous
with the EGRET observations between 1993 October 19 and 1994 January 3 (MJD 49279 -
49355). For example, the closest IUE data available are from 1994 January 8 (MJD 49360;
see Table 6) and the OSSE spectrum is from 1993 December 20 to 27 (MJD 49341 – 49348;
Table 7). Anyway, one should bear in mind that the time spans involved in deriving a
spectrum from a source are very different from one wavelength range to the other. In the
$\gamma$-ray range for example the spectrum has been derived from data accumulated over at least
one week, while in the other wavelength ranges spectra can be derived on timescales of one
day and less. For this reason alone the $\gamma$-ray spectrum can never be truly simultaneous to
the other multiwavelength spectra. In order to be truly simultaneous the sampling times
should be of the same order.

The overall spectrum of 3C 273 during the phase 3 observations (Fig. 3) is similar to
that during 1991 June (VP 3) in phase 1 (Lichti et al. 1995). The multiwavelength energy
density spectrum ($\nu F_\nu$ spectrum) shows probably four maxima: the first around 3\cdot$10^{11}$ Hz
(corresponding to the mm — sub-mm range), the second maximum (although not observed)
must be between 10$^{12}$ Hz and \approx 10$^{14}$ Hz, the third maximum is the “blue bump” at about
3\cdot$10^{15}$ Hz and the fourth maximum is reached in the MeV region between 1 and 10 MeV. It
is the first maximum, in the mm – sub-mm range, which was at a relatively low level during
the $\gamma$-ray ‘flare’. So far, it is not at all clear whether this observation fits the theoretical
explanations for the production of the high energy $\gamma$-rays.

In order to determine the break energy and the change in spectral index between
the hard X-rays and the high energy $\gamma$-rays, the energy spectrum beyond 2 keV has been
fitted with the same broken power law already used by Lichti et al. (1995). The measured
energy spectrum is rather well represented by the following (empirical) function (Fig. 3; the
reduced $\chi^2$ for this fit is $\chi^2/dof = 1.04$ with 15 degrees of freedom):

$$F_\nu = (1.66 \pm 0.87) \cdot 10^{-4} \frac{(E/E_b)_{MeV}^{-0.629\pm0.038}}{1 + (E/E_b)_{MeV}^{0.97\pm0.07}} \ [mJy]$$
Where $E_b$ has a value of $(2.36 \pm 1.28)$ MeV. The fit function indicates a steepening of the energy spectrum by $0.97 \pm 0.07$ for $E >> 2$ MeV. This is somewhat more than the value from Lichti et al. (1995) which was $0.8 \pm 0.03$ for $E >> 1$ MeV (Fig. 3).

4.2.1. Model fits

In order to test the different models for the generation of $\gamma$-rays in the jets of AGN we have fitted the observed spectrum with (i) a synchrotron self-Compton (SSC) model, (ii) an external Compton (EC) model, and (iii) a proton-initiated cascade (PIC) model. The basic assumptions for the jet in all these models are the same as in Blandford & Königl (1979): a conical relativistic and magnetized jet in which accelerated electrons produce a flat radio synchrotron spectrum (owing to a synchrotron-self-absorption turnover frequency decreasing inversely proportional to the jet radius) breaking by one power in the mm-to-infrared range due to energy losses steepening the accelerated electron spectrum.

(i) The SSC model: The relativistic jet SSC calculations are described by Marscher and Travis (1996). The jet is modeled as a truncated cone with a power-law electron spectrum injected at the inner radius. The density falls off as $1/r^2$, the magnetic field as $1/r$, and the electron energies decay from adiabatic, synchrotron, and inverse Compton losses. This provides a smooth-jet approximation to the knotty structure observed with VLBI.

For the model fit, the following parameters have been fixed: Opening half-angle of the jet ($0.5^\circ$), angle between the jet axis and the line of sight ($6^\circ$), bulk Lorentz factor 9.3, minimum injected electron energy corresponding to $\gamma_{\text{min}} = 100$. The following parameters were determined by the fitting procedure: Injected power-law of electron energy distribution $s = 2.3$, ratio of randomly oriented to axial component of magnetic field: 1.5; the values at the injection point of the parameters that change with radius are: Cross-sectional radius $r = 0.055$ pc, magnetic field $B = 0.023$ G, density of relativistic electrons $n_e = 180$ cm$^{-3}$, and the maximum injected electron energy $\gamma_{\text{max}} = 2.5 \times 10^4$.

Hence, 6 parameters were varied until a good fit (Fig. 7) was obtained. We required that the model fit the self-absorption turnover frequency and the overall spectral shape. This places strong constraints on the values of the critical parameters. Nevertheless, we cannot be certain that the fit is the best one possible. The $\chi^2$ for this fit is 270 with 22 degrees of freedom. This applies to the frequency range $3.7 \times 10^{10}$ to $2 \times 10^{14}$ Hz and $1 \times 10^{18}$ to $1 \times 10^{24}$ Hz. There was no attempt to fit the optical-UV spectrum, since it is obviously dominated by the big blue bump. The main contributions to the high $\chi^2$ are several points that are poorly fit but have very low observational uncertainty. The $\chi^2$ test indicates that
the fit is not particularly good in detail. However, we are only using an ideal model with a small number of free parameters that can provide a global fit rather than a more complex model designed to fit each point as closely as possible.

We therefore conclude that an SSC-emitting relativistic jet model can reproduce the general shape of the multiwaveband spectrum of 3C 273. This is true even though the physics of the energy losses and radiative transfer are fixed ab initio.

(ii) The EC-model: In this model, the (steady) electron distribution $N(\gamma)$ has been derived using the continuity equation as well as considering cooling, escape, pair production etc. (Ghisellini et al. 1996). In this case one obtains a broken power law because electrons below the minimum injected $\gamma_{\text{min}}$ have a $\gamma^{-2}$ distribution, while electrons above $\gamma_{\text{min}}$ have $\gamma^{(-s-1)}$, where $s$ is the slope of the injected electrons. In this case it is assumed that electrons are injected continuously, with a power law energy distribution with slope $s = 3.3$ between $\gamma_{\text{min}} = 80$ and $\gamma_{\text{max}} = 10^4$. This results in an equilibrium distribution which is a broken power law, with index 2 for $\gamma < \gamma_{\text{min}}$, and around 4.3 above. The blob sees photons coming from outside, [i.e. photons from the broad line region (BLR)], distributed as a diluted blackbody.

Figure 8 shows the result of the fit of this model to the data. The parameters of the model are: Dimension of the source $R = 2 \cdot 10^{16}$ cm, magnetic field $B = 5.9$ G, injected luminosity $L_i = 3.7 \cdot 10^{44}$ erg/s (intrinsic), beaming factor $D = 6.5$ (assumed to be equal to the bulk Lorentz factor) and the ratio of external radiation energy density to magnetic energy density $U'_{\text{ext}}/U_B = 11/5.5 = 2$ (in the comoving frame of the blob). The blackbody in the figure corresponds to the relevant disk emission, which illuminates the BLR. The $\chi^2$ for this fit [considering only the points above $\log(\nu)=15$, and excluding the point in the soft X-rays at $\log(\nu)=16.477$], is 108.84. Assuming 6 interesting, adjustable parameters ($R$, $B$, $\gamma_{\text{min}}$, $\gamma_{\text{max}}$, slope of the injected electron distribution, and $R_{\text{BLR}}$), the reduced $\chi^2$ for this fit is $\chi^2/dof = 7.78$.

The Compton spectrum is not completely smooth, because it is the sum of internal SSC and external Compton. One can see the contribution of the internal SSC at $\nu \sim 10^{16}$ Hz. Electrons with $\gamma < 100$ emit self-absorbed synchrotron radiation, and therefore one does not see the synchrotron emission of the electrons below the break.

Due to the simplicity of this one–zone, homogeneous model, we made no attempt to fit the radio, the far IR and the soft X–ray excess emission. Additional, larger, non-thermal components are needed to model the far IR and the radio data, and another (maybe thermal) component must be responsible for the soft–ray excess. Furthermore, there is no intention to model the UV–bump emission correctly with some theory.
The value of the derived $\chi^2$ can be considered only a very rough measure of the goodness of the fit, given the simplicity of the model, the maybe unrealistically small error bars on some data points (especially in the MeV band) and the fact that not all data points are strictly simultaneous.

(iii) PIC-model: Figure 3 shows a fit to the 3C 273 multifrequency data adopting the proton blazar model \textit{Mannheim} 1993b). In this model, $\gamma$-rays emerge as the end-product of cascades initiated by ultra-relativistic protons suffering inelastic collisions with low energy synchrotron photons, which appear in the proton rest frame with energies above threshold for secondary pair and pion production. The proton-initiated emission is treated in a one-zone approximation in which the cascades are assumed to occur only at the jet radius where the infrared synchrotron photons (acting as a target for the ultra-relativistic protons) become optically thin. In the present model fit, the jet radius computed from the fit parameters is $r_{\perp} = 10^{17}$ cm (the distance to the central black hole is undetermined).

Fitting the low energy part of the spectrum as electron synchrotron emission yields a jet Lorentz factor $\gamma_j = 8$, angle to the line-of-sight $\theta = 7^\circ$, opening angle of the jet $\Phi' = 2^\circ$ and a relativistic particle luminosity $L_j = 1.4 \times 10^{46}$ ergs s$^{-1}$. The proton-to-electron ratio was forced to be $\eta = 100$ allowing for a calculation of the equipartition magnetic field strength $B'_{eq} = 0.8$ G and the synchrotron break frequency in the comoving frame $\nu'_b = 2 \times 10^{10}$ Hz.

Fitting the high-energy part of the spectrum yields the ratio of the proton and electron cooling rates ($\xi = 0.15$) considering that the cascade luminosity emerging in the X-ray and $\gamma$-ray bands equals $L_p = \eta \xi L_e$ where $L_e$ denotes the primary electron synchrotron luminosity (radio-to-UV). From the value of $\xi$, one obtains a proton maximum Lorentz factor of $\gamma_{p,max} = 3 \times 10^{10}$.

In addition to the jet spectrum, an accretion disk spectrum with $S_\nu \propto \nu^{+1/3}$ in the optical-to-UV range has been assumed. The inferred thermal-to-nonthermal luminosity ratio is of order unity. The disk spectrum turns over steeply at 20 eV turning into a power law $S_\nu \propto \nu^{-2}$. This kind of soft X-ray spectrum is expected to emerge from a disk covered by a marginally optically thick jet base \textit{Mannheim, Schulte, & Rachen} 1995).

Also $\gamma$-ray attenuation by interaction of the jet $\gamma$-rays with photons from the jet environment has been taken into account. This is important, since the proton blazar spectrum tends to overproduce $\gamma$-rays above $\sim 100$ MeV, and especially at TeV energies. In the fit, attenuation by diffuse intergalactic light and by scattered disk radiation has been taken into account. The former leads to a quasi-exponential cutoff at $\sim 7 \times 10^{11}$ eV \textit{Mannheim et al.} 1996, the latter is characterized by an optical depth
\[ \tau_{\gamma\gamma} = 0.01 (\epsilon/100 \text{MeV})^{1/2} L_{46} \tau_{-2} \]  
(Dermer & Schlickeiser, 1994) leading to a steepening by \( \Delta s = 0.5 \) in the GeV range \((L_{46} = 3, \tau_{-2} = 5)\). Thus, although in the proton blazar model \(\gamma\)-rays could in principle be produced at an arbitrary distance from the central black hole (provided that the jet is collimated enough to produce infrared synchrotron photons of high density), the spectrum of 3C 273 indicates that the flux of \(\gamma\)-rays is attenuated by traversing the central radiation field. The occasionally observed flattening of the \(\gamma\)-ray spectrum is naturally explained as the signature of a \(\gamma\)-ray emitting shock traveling along the jet away from the central source of thermal radiation, thereby experiencing a decreasing external pair creation optical depth.

Owing to the coarse construction of the model, fine details of the spectrum in the radio-to-infrared and optical-to-UV bands are not well reproduced. They could be fitted with much higher accuracy taking into account jet inhomogeneities and an accretion disk for which published models exist. Such refinements for the proton-initiated cascade part of the model would probably also remove the significant residual at 1-10 MeV which is responsible for the moderate \(\chi^2/\nu = 32/20\) of the fit in the X-ray-to-\(\gamma\)-ray regime.

5. Discussion

The increase in \(\gamma\)-ray flux is much slower for 3C 273 than that observed from 3C 279 during its 1991 June flare where the flux increased by a factor of 4 within about 7 days (Kniffen et al. 1993). On the other hand the difference in peak flux from the two sources is about a factor of 7. While in 3C 279 we may have seen only the top of the flare, it is more likely that in the case of 3C 273 we have seen only the initial rise of a flare. One could therefore argue that a \(\gamma\)-ray flare might consist of two parts: a slowly increasing part (as observed in 3C 273) followed by a more eruptive part with a steep decrease at the end as observed in 3C 279 (Kniffen et al. 1993). Such an eruptive part could have easily fit into the two weeks following 1993 December 1 when 3C 273 was not observed by EGRET.

But it could also be that the shape and intensity of the flare is related to the temporal behaviour at lower frequencies: In the case of 3C 279 there was a possible correlation of the \(\gamma\)-ray flare with a short synchrotron flare in the R-band (McHardy et al. 1996, Hartman et al. 1996) while in the case of 3C 273 the increase in flux might have been correlated with the much slower second radio outburst components at 22 and 37 GHz. A similar behavior was observed for the quasar PKS 0528+134 where also a radio outburst at 22 and 37 GHz followed the \(\gamma\)-ray flare (Pohl et al. 1995, Mukherjee et al. 1996). Further flares have to be observed before any of these hypotheses can be confirmed.
As already noted by Courvoisier et al. (1987, 1990) the temporal behaviour is very complex in all wavebands with a few correlations, none conclusive mainly because the light curves are undersampled in most cases (especially at shorter wavelengths). Our observations are no exception. From the temporal behavior of 3C 273 during this observational campaign across the entire electromagnetic spectrum one cannot deduce any correlation or anti-correlation of the high energy end with the lower energies, except maybe for the 14.5 GHz, 22 and 37 GHz regime. Statistical investigations of the temporal behavior of all the γ-ray emitting AGN seem to support a relation with the 22 and 37 GHz regime (Valtaoja & Teräsranta 1995, Mücke et al. 1996b) although there is no one-to-one correlation.

The decrease of the flux in the sub-mm and mm-regime during the flux increase in the γ-ray regime is probably coincidental, but still represents a problem for the homogeneous SSC models in which changes in intensity (though different in amount) should go in the same direction for all frequencies.

Courvoisier et al. (1987, 1990) already excluded the homogeneous SSC models for 3C 273 because of the lack of mm-X-ray correlations at zero lag. They concluded that this lack of correlation could only be explained with either two different electron components (one for the synchrotron, one for the X-rays) OR a second source of photons which dominates the photon energy density in the synchrotron region. This second source of photons would naturally be explained by the EC-models, the second electron component would naturally follow from the proton-induced cascade models where the X- and γ-rays can be produced by completely different particle populations.

Although the increase of the γ-ray intensity was larger than the increase in the synchrotron emission (except for the decrease in the sub-mm and mm-regime), which is qualitatively consistent with the expectations from the SSC models (e.g. Maraschi et al. 1994), the SSC model has to assume either inhomogeneous emission regions or a broken power law for the spectrum of the relativistic electrons (Ghisellini et al. 1996) in order to account for the – in general – two peaks (one in the IR-optical and one in the γ-ray regime (see e.g. von Montigny et al. 1995)) in the overall spectral energy distribution of the γ-ray emitting AGN. 3C 273 has at least three (maybe even four) peaks in its spectral energy distribution, indicating an even more complicated situation and maybe even as many as four different emission mechanisms (Courvoisier et al. 1987).

The attempts of fitting the observed multiwavelength spectrum of 3C 273 with theoretical models also show that the spectrum can not be well represented without

\footnote{Another very prominent quasar for which such a lack of mm-X-ray correlation is known is 3C 345 (Bregman et al. 1986).}
the contribution of several components. For example, the “big blue bump” peaking at \( \approx 3 \cdot 10^{15} \text{Hz} \) may be indicating the presence of a massive accretion disk providing copious possible target photons for the relativistic particles in the jet. All three models are capable of representing the MeV-Bump within the errors. In the X-ray/\( \gamma \)-ray range, the data cannot be fit well by a smooth SSC spectrum within the 1 \( \sigma \) error bars but including the big blue bump and first order Comptonization of these photons might improve the situation in that regime. The EC-model has some difficulties to account for the low energy range between \( 10^9 < \nu < 10^{14} \) and also the extreme UV range without assuming at least additional emission sites. The PIC-model yields the best overall fit of the multiwavelength spectrum over more than 17 decades with only three necessary components. Another possibility to generate the high \( \gamma \)-ray emission which has not been mentioned yet is the Comptonization of the “big blue bump” by a monoenergetic relativistic electron outflow involving multiple inverse Compton scattering (Titarchuk & Lyubarskij 1995, Ramos et al. 1996).

Although this campaign has the by far best coverage across the entire electromagnetic spectrum the data are still insufficient to discriminate between all the possible emission models for the high \( \gamma \)-ray emission. What is still missing is a truly simultaneous and regular monitoring of 3C 273 (and other blazars) at all frequencies before, during and after a flare in high energy \( \gamma \)-rays. The more we learn about 3C 273 and other \( \gamma \)-ray emitting quasars the more it is becoming evident that 3C 273 is far from being a standard quasar.

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Fig. 1.— Comparison of spectra of 3C 273 during VP 305.0 (asterisks) and VP 308.6 (squares). It can be seen that the increase in flux comes from a hardening of the spectrum.

Fig. 2.— Spectral indices versus integral flux above 100 MeV for 3C 273. There is evidence that the γ-ray spectra harden with increasing flux.

Fig. 3.— Time histories of 3C 273.

Fig. 4.— mm- and sub-mm fluxes of 3C 273 during the EGRET observations.

Fig. 5.— Quasi-simultaneous multiwavelength spectrum of 3C 273. The data in the radio through UV range have not been averaged.

Fig. 6.— High energy spectrum of 3C 273. The solid line is the result from the fit in this paper and the dashed line is the fit from Lichti et al. (1995).

Fig. 7.— Fit of the SSC-model to the observed spectrum of 3C 273. Parameters of the model are: cross-sectional radius $r = 0.055$ pc, opening half-angle of the jet: $0.5^\circ$, angle between the jet axis and the line of sight: $6^\circ$, bulk Lorentz factor: $9.3$, minimum injected electron energy $\gamma_{\text{min}} = 100$, maximum injected electron energy $\gamma_{\text{max}} = 2.5 \cdot 10^4$, injected power-law of electron energy distribution: $2.3$, density of relativistic electrons $N_e = 180$ cm$^{-3}$, magnetic field $B = 0.023$ G, ratio of randomly oriented to axial component of magnetic field: $1.5$.

Fig. 8.— Fit of the EC-model to the observed spectrum of 3C 273. Parameters of the model are: Dimension of the source $R = 2 \cdot 10^{16}$ cm, magnetic field $B = 5.9$ G, injected luminosity $L_i = 3.7 \cdot 10^{44}$ erg/s, beaming factor $D = 6.5$, $U_{\text{ext}}/U_B = 2$.

Fig. 9.— Fit of the PIC-model to the observed spectrum of 3C 273. Parameters of the model are: Jet radius $r_\perp = 10^{17}$ cm, jet Lorentz factor $\gamma_j = 8$, angle to the line of sight $\theta = 7^\circ$, relativistic particle luminosity $L_j = 1.4 \cdot 10^{46}$ erg/s, proton to electron ratio $\eta = 100$, equipartition magnetic field strength $B'_{\text{eq}} = 0.8$ G, ratio of proton and electron cooling rates $\xi = 0.15$, maximum proton Lorentz factor $\gamma_{p,\text{max}} = 3 \times 10^{10}$.
Table 1. EGRET fluxes of 3C 273 from phases 1, 2, 3, and cycle 4.

| Viewing Period | Time of Observation | MJD     | Offset (deg) | Signif. $\sqrt{TS}$ | Flux (E > 100 MeV) |
|----------------|---------------------|---------|--------------|----------------------|--------------------|
| 3.0            | 06/15/91 - 06/28/91 | 48422-48435 | 4.29         | 6.7                  | 23.8±4.5           |
| 11.0           | 10/03/91 - 10/17/91 | 48532-48546 | 2.00         | 2.5                  | < 17.7             |
| 204.0          | 12/22/92 - 12/29/92 | 48978-48685 | 3.28         | 0.5                  | < 18.2             |
| 205.0          | 12/29/92 - 01/05/93 | 48685-48992 | 3.46         | 2.3                  | < 33.2             |
| 206.0          | 01/05/93 - 01/12/93 | 48992-48999 | 3.28         | 2.5                  | < 46.5             |
| 204.0 ... 206.0| 12/22/92 - 01/12/93|                     |              |                      |                   |
| 304.0          | 10/19/93 - 10/25/93 | 49279-49285 | 5.38         | 3.0                  | < 44.0             |
| 305.0          | 10/25/93 - 11/02/93 | 49285-49293 | 5.69         | 3.4                  | 20.7±8.1           |
| 306.0          | 11/02/93 - 11/09/93 | 49293-49300 | 8.14         | 2.8                  | < 42.0             |
| 304.0 ... 306.0| 10/19/93 - 11/09/93|                     |              |                      |                   |
| 307.0          | 11/09/93 - 11/16/93 | 49300-49307 | 9.62         | 4.1                  | 35.1±12.0          |
| 308.0          | 11/16/93 - 11/19/93 | 49307-49310 | 10.54        | 2.3                  | < 68.0             |
| 307.0 ... 308.0| 11/09/93 - 11/19/93|                     |              |                      |                   |
| 308.6          | 11/23/93 - 12/01/93 | 49314-49322 | 10.54        | 6.7                  | 55.7±11.9          |
| 311.0          | 12/13/93 - 12/15/93 | 49334-49336 | 10.37        | 0.0                  | < 34.0             |
| 311.6          | 12/17/93 - 12/20/93 | 49338-49341 | 10.37        | 1.7                  | < 61.0             |
| 311.0 ... 311.6| 12/13/93 - 12/20/93|                     |              |                      |                   |
| 312.0          | 12/20/93 - 12/27/93 | 49341-49348 | 7.28         | 0.4                  | < 21.6             |
| 313.0          | 12/27/93 - 01/03/94 | 49348-49355 | 14.34        | 0.2                  | < 23.7             |
| 311.6 ... 312.0| 12/17/93 - 12/27/93|                     |              |                      |                   |
| 311.0 ... 313.0| 12/13/93 - 01/03/94|                     |              |                      |                   |
| 405.0          | 11/29/94 - 12/07/94 | 49685-49693 | 11.30        | 0.0                  | < 10.1             |
| 406.0          | 12/13/94 - 12/20/94 | 49699-49706 | 18.77        | 0.0                  | < 23.6             |
| 407.0          | 12/20/94 - 01/03/95 | 49706-49720 | 19.33        | 0.0                  | < 18.7             |
| 408.0          | 01/03/95 - 01/10/95 | 49720-49727 | 10.36        | 1.6                  | < 26.9             |
Table 2. Results of spectral analysis.

| Viewing Period | Spectral Index ($\Gamma_\gamma$) | $N_o$ ($10^{-9}$ photons cm$^{-2}$s$^{-1}$ MeV$^{-1}$) | $E_o$ (MeV) | $\chi^2/n_f$ |
|----------------|---------------------------------|---------------------------------|-------------|--------------|
| 305.0          | 3.20± 0.54                      | 4.62± 1.23                      | 102.7       | 0.71         |
| 304.0 ... 306.0| 2.93± 0.33                      | 1.75± 0.36                      | 123.0       | 0.46         |
| 307.0          | 2.83± 0.35                      | 6.83± 1.41                      | 110.1       | 0.35         |
| 307.0 ... 308.0| 2.69± 0.32                      | 6.84± 1.33                      | 118.4       | 0.53         |
| 308.6          | 2.20± 0.22                      | 0.96± 0.19                      | 225.7       | 0.63         |
| 304.0 ... 308.6| 2.59± 0.15                      | 1.58± 0.18                      | 155.3       | 0.75         |
Table 3a. 2.7, 4.75 and 10.55 GHz radio data for 3C 273 (Pohl, Reich).

| MJD   | 2.7 GHz |           | 4.75 GHz |           | 10.55 GHz |           |
|-------|---------|-----------|----------|-----------|-----------|-----------|
|       | Flux(Jy) | σ(Jy)     | Flux(Jy)  | σ(Jy)     | Flux(Jy)  | σ(Jy)     |
| 48335 | ...      | ...       | 33.40    | 0.50      | ...       | ...       |
| 48536 | 42.10    | 3.00      | 33.90    | 0.70      | 44.00     | 2.50      |
| 48567 | 37.10    | 0.60      | 34.00    | 0.70      | ...       | ...       |
| 48588 | 39.40    | 1.70      | 35.20    | 1.20      | 45.70     | 1.20      |
| 48602 | 41.50    | 1.00      | 35.60    | 0.40      | 43.50     | 2.20      |
| 48673 | 40.00    | 2.70      | 36.50    | 1.50      | 44.90     | 3.00      |
| 48685 | 38.70    | 2.90      | ...      | ...       | 45.70     | 4.80      |
| 48726 | 39.30    | 1.00      | ...      | ...       | 47.10     | 2.50      |
| 48741 | 38.90    | 1.10      | 36.70    | 1.30      | 46.90     | 2.90      |
| 48775 | 41.70    | 1.60      | 39.80    | 1.80      | 46.50     | 2.30      |
| 48799 | 40.40    | 2.20      | ...      | ...       | 43.30     | 4.00      |
| 48819 | ...      | ...       | ...      | ...       | 47.00     | 1.00      |
| 48883 | ...      | ...       | ...      | ...       | 45.00     | 1.00      |
| 48904 | 40.80    | 1.50      | ...      | ...       | 44.80     | 1.00      |
| 48966 | 40.00    | 1.30      | 40.60    | 1.50      | 43.00     | 2.00      |
| 48967 | ...      | ...       | ...      | ...       | 44.80     | 2.00      |
| 48996 | 41.70    | 1.80      | 42.00    | 1.40      | 43.90     | 1.00      |
| 48997 | 42.20    | 1.60      | 41.60    | 1.40      | 45.60     | 2.20      |
| 49027 | 41.90    | 1.60      | 41.90    | 2.20      | 44.80     | 2.70      |
| 49056 | ...      | ...       | ...      | ...       | 43.40     | 2.20      |
| 49071 | 43.20    | 1.70      | 42.40    | 1.90      | 43.00     | 2.40      |
| 49108 | 42.30    | 1.70      | 43.00    | 2.30      | 41.10     | 1.50      |
| 49158 | ...      | ...       | 43.20    | 1.30      | 41.70     | 1.50      |
| 49184 | 42.80    | 1.10      | ...      | ...       | ...       | ...       |
| 49185 | 42.80    | 1.20      | 43.20    | 1.80      | 41.40     | 1.50      |
| 49217 | 43.60    | 1.50      | 43.80    | 1.80      | ...       | ...       |
| 49218 | 43.00    | 1.50      | ...      | ...       | ...       | ...       |
| 49219 | 45.90    | 1.70      | ...      | ...       | 40.50     | 2.00      |
| 49297 | 45.70    | 2.10      | 41.60    | 1.70      | 40.90     | 2.70      |
| 49299 | ...      | ...       | 43.10    | 1.70      | 39.30     | 2.10      |
| 49332 | 44.80    | 1.40      | ...      | ...       | ...       | ...       |
| 49349 | 44.80    | 1.70      | 42.70    | 1.60      | 39.80     | 1.60      |
| 49381 | 45.00    | 1.40      | 42.30    | 1.20      | 40.30     | 1.90      |
| 49413 | 44.70    | 1.60      | 42.80    | 1.60      | 39.70     | 1.80      |
| MJD  | 2.7 GHz | 4.75 GHz | 10.55 GHz |
|------|---------|----------|-----------|
|      | Flux(Jy) | σ(Jy)    | Flux(Jy)  | σ(Jy)    | Flux(Jy) | σ(Jy)    |
| 49430| 44.30    | 1.60     | 43.40     | 1.60     | 41.50    | 2.00     |
| 49713| 46.30    | 2.60     | 43.00     | 2.50     | ...      | ...      |
| 49756| 45.90    | 1.90     | 41.10     | 1.30     | ...      | ...      |
Table 3b. 4.8 GHz light curve for 3C 273 (Aller & Aller).

| MJD  | Flux  | σ  |
|------|-------|----|
|      | (Jy)  | (Jy) |
| 48929 | 41.20 | 0.34 |
| 48938 | 41.49 | 0.49 |
| 48950 | 41.58 | 0.50 |
| 48952 | 41.65 | 0.25 |
| 48968 | 41.54 | 0.34 |
| 48990 | 41.51 | 0.44 |
| 49010 | 42.23 | 0.30 |
| 49052 | 42.43 | 0.36 |
| 49053 | 42.04 | 0.43 |
| 49066 | 41.93 | 0.80 |
| 49078 | 42.50 | 0.40 |
| 49083 | 43.06 | 0.41 |
| 49127 | 43.57 | 0.28 |
| 49128 | 43.17 | 0.28 |
| 49132 | 43.13 | 0.40 |
| 49139 | 43.73 | 0.22 |
| 49148 | 43.77 | 0.41 |
| 49156 | 44.16 | 0.41 |
| 49159 | 43.78 | 0.42 |
| 49168 | 43.80 | 0.52 |
| 49176 | 43.13 | 0.38 |
| 49177 | 44.67 | 0.48 |
| 49192 | 42.91 | 0.64 |
| 49198 | 43.92 | 0.34 |
| 49205 | 44.32 | 0.53 |
| 49206 | 43.54 | 0.31 |
| 49215 | 43.65 | 0.38 |
| 49222 | 42.94 | 0.48 |
| 49295 | 42.73 | 0.23 |
| 49318 | 42.69 | 0.25 |
| 49326 | 42.81 | 0.32 |
| 49336 | 42.12 | 0.26 |
| 49352 | 42.04 | 0.32 |
| 49354 | 42.53 | 0.23 |
Table 3b—Continued

| MJD  | Flux (Jy) | $\sigma$ (Jy) |
|------|-----------|---------------|
| 49365| 42.62     | 0.31          |
| 49377| 42.15     | 0.24          |
| 49400| 42.86     | 0.32          |
| 49416| 42.59     | 0.30          |
| 49423| 42.85     | 0.24          |
| 49440| 42.22     | 0.28          |
| 49448| 42.43     | 0.40          |
| 49454| 42.32     | 0.21          |
| 49467| 42.09     | 0.19          |
| 49471| 43.01     | 0.25          |
| 49482| 42.99     | 0.25          |
| 49498| 42.86     | 0.33          |
| 49516| 43.42     | 0.29          |
| 49519| 43.50     | 0.19          |
| 49520| 43.02     | 0.25          |
| 49531| 43.41     | 0.25          |
| 49569| 43.25     | 0.27          |
| 49575| 42.81     | 0.20          |
| 49583| 42.67     | 0.37          |
| 49737| 41.18     | 0.69          |
| 49769| 41.80     | 0.82          |
| 49783| 43.28     | 1.06          |
Table 3c. 8 GHz light curve for 3C 273 (Aller & Aller).

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 48927 | 49.59     | 0.58   |
| 48935 | 46.48     | 0.44   |
| 48951 | 47.25     | 0.47   |
| 48955 | 46.98     | 0.31   |
| 48969 | 44.50     | 0.44   |
| 48981 | 47.60     | 0.48   |
| 48982 | 47.32     | 0.42   |
| 48988 | 47.47     | 0.35   |
| 48994 | 47.15     | 0.40   |
| 49001 | 43.51     | 0.49   |
| 49007 | 48.31     | 0.45   |
| 49019 | 50.39     | 0.80   |
| 49020 | 47.38     | 0.65   |
| 49037 | 47.32     | 0.34   |
| 49058 | 46.38     | 0.43   |
| 49071 | 46.59     | 0.48   |
| 49086 | 48.22     | 0.54   |
| 49114 | 47.03     | 0.51   |
| 49122 | 47.06     | 0.56   |
| 49150 | 46.01     | 0.60   |
| 49152 | 46.69     | 0.46   |
| 49161 | 47.14     | 0.57   |
| 49168 | 48.38     | 0.55   |
| 49178 | 47.47     | 0.67   |
| 49190 | 45.92     | 0.44   |
| 49200 | 46.51     | 0.39   |
| 49207 | 46.60     | 0.48   |
| 49209 | 46.90     | 0.45   |
| 49217 | 45.84     | 0.54   |
| 49226 | 47.12     | 0.43   |
| 49237 | 46.55     | 0.65   |
| 49243 | 45.03     | 0.47   |
| 49294 | 44.28     | 0.51   |
| 49301 | 45.10     | 0.33   |
Table 3c—Continued

| MJD | Flux (Jy) | σ (Jy) |
|-----|-----------|--------|
| 49305 | 44.14 | 0.44 |
| 49322 | 42.85 | 0.78 |
| 49334 | 44.12 | 0.72 |
| 49346 | 44.53 | 0.50 |
| 49347 | 44.45 | 0.47 |
| 49360 | 43.20 | 0.46 |
| 49368 | 45.24 | 0.37 |
| 49385 | 44.86 | 0.66 |
| 49414 | 44.15 | 0.79 |
| 49415 | 45.10 | 0.81 |
| 49421 | 45.79 | 0.63 |
| 49430 | 43.47 | 0.51 |
| 49431 | 44.00 | 0.62 |
| 49434 | 45.33 | 0.41 |
| 49447 | 45.46 | 0.33 |
| 49453 | 44.85 | 0.49 |
| 49461 | 44.58 | 0.53 |
| 49462 | 45.15 | 0.53 |
| 49476 | 44.17 | 0.44 |
| 49491 | 44.40 | 0.43 |
| 49506 | 43.84 | 0.51 |
| 49514 | 42.59 | 0.82 |
| 49518 | 42.49 | 0.55 |
| 49539 | 43.32 | 0.65 |
| 49561 | 43.55 | 0.36 |
| 49572 | 42.39 | 0.34 |
| 49573 | 43.29 | 0.48 |
| 49586 | 42.27 | 0.39 |
| 49588 | 41.93 | 0.85 |
| 49589 | 45.45 | 0.87 |
| 49593 | 44.02 | 0.52 |
| 49594 | 42.06 | 0.50 |
| 49595 | 41.56 | 0.51 |
| 49650 | 42.43 | 0.39 |
| MJD | Flux (Jy) | $\sigma$ (Jy) |
|-----|-----------|----------------|
| 49651 | 42.16     | 0.34           |
| 49670 | 42.39     | 0.48           |
| 49672 | 42.36     | 0.37           |
| 49689 | 41.61     | 0.73           |
| 49705 | 40.09     | 0.86           |
| 49708 | 40.70     | 0.57           |
| 49709 | 40.08     | 0.68           |
| 49710 | 41.36     | 0.35           |
| 49711 | 42.38     | 0.48           |
| 49712 | 40.46     | 0.43           |
| 49736 | 39.38     | 0.41           |
| 49753 | 41.11     | 0.34           |
| 49756 | 39.92     | 0.31           |
| 49762 | 40.57     | 0.45           |
| 49765 | 40.66     | 0.33           |
| 49766 | 39.99     | 0.40           |
| 49780 | 40.70     | 0.29           |
| 49781 | 40.00     | 0.27           |
Table 3d. 14.5 GHz light curve for 3C 273 (Aller & Aller).

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 48930 | 45.36     | 0.30   |
| 48937 | 45.52     | 0.32   |
| 48946 | 46.28     | 0.57   |
| 48963 | 45.54     | 0.40   |
| 48975 | 44.95     | 0.61   |
| 48979 | 45.72     | 0.35   |
| 48986 | 45.71     | 0.44   |
| 48988 | 46.83     | 0.67   |
| 49048 | 43.00     | 0.35   |
| 49050 | 43.40     | 0.53   |
| 49059 | 42.78     | 0.49   |
| 49068 | 40.86     | 0.67   |
| 49090 | 40.32     | 0.38   |
| 49106 | 39.35     | 0.46   |
| 49109 | 36.65     | 0.52   |
| 49124 | 43.54     | 0.50   |
| 49130 | 37.66     | 0.48   |
| 49142 | 41.87     | 1.02   |
| 49152 | 38.34     | 0.39   |
| 49165 | 39.49     | 0.53   |
| 49175 | 38.45     | 0.81   |
| 49185 | 40.42     | 0.81   |
| 49194 | 39.31     | 0.79   |
| 49202 | 40.91     | 1.06   |
| 49213 | 39.64     | 0.93   |
| 49220 | 37.27     | 0.47   |
| 49231 | 35.05     | 0.70   |
| 49275 | 36.75     | 1.04   |
| 49292 | 37.84     | 1.10   |
| 49300 | 39.41     | 0.49   |
| 49310 | 38.69     | 0.69   |
| 49311 | 39.47     | 0.34   |
| 49312 | 36.38     | 0.57   |
| 49329 | 40.19     | 0.48   |
Table 3d—Continued

| MJD | Flux (Jy) | $\sigma$ (Jy) |
|-----|-----------|---------------|
| 49343 | 41.14 | 0.36 |
| 49350 | 40.43 | 0.69 |
| 49363 | 44.25 | 0.75 |
| 49370 | 41.77 | 0.71 |
| 49393 | 41.07 | 0.34 |
| 49412 | 41.67 | 0.39 |
| 49417 | 41.49 | 0.67 |
| 49419 | 41.84 | 0.38 |
| 49441 | 39.09 | 0.29 |
| 49450 | 40.22 | 0.41 |
| 49458 | 39.94 | 1.13 |
| 49475 | 38.38 | 0.44 |
| 49478 | 40.27 | 0.79 |
| 49486 | 38.25 | 0.78 |
| 49503 | 37.83 | 0.42 |
| 49505 | 36.85 | 0.28 |
| 49508 | 37.11 | 0.53 |
| 49512 | 37.22 | 0.63 |
| 49513 | 36.88 | 0.97 |
| 49535 | 34.40 | 0.73 |
| 49547 | 35.63 | 0.28 |
| 49551 | 35.40 | 0.48 |
| 49564 | 36.80 | 0.43 |
| 49604 | 32.65 | 0.74 |
| 49654 | 33.34 | 0.77 |
| 49664 | 33.63 | 0.34 |
| 49714 | 34.59 | 0.47 |
| 49743 | 33.00 | 0.38 |
| 49768 | 32.10 | 0.35 |
| 49777 | 32.32 | 0.32 |
| 49779 | 32.32 | 0.40 |
Table 3e. 22 GHz light curve for 3C 273 (Teräsranta, Tornikoski, Valtaoja).

| MJD    | Flux (Jy) | σ (Jy) |
|--------|-----------|--------|
| 48305  | 38.62     | 0.79   |
| 48315  | 38.16     | 0.65   |
| 48324  | 40.11     | 0.63   |
| 48357  | 41.84     | 0.64   |
| 48371  | 42.45     | 0.59   |
| 48391  | 45.34     | 0.68   |
| 48410  | 47.34     | 1.48   |
| 48418  | 51.47     | 1.33   |
| 48438  | 49.58     | 1.49   |
| 48449  | 48.95     | 1.56   |
| 48459  | 52.22     | 1.54   |
| 48466  | 53.07     | 1.36   |
| 48473  | 55.58     | 1.66   |
| 48483  | 56.09     | 2.37   |
| 48494  | 55.37     | 1.68   |
| 48501  | 55.98     | 1.33   |
| 48555  | 53.36     | 0.98   |
| 48583  | 50.37     | 1.09   |
| 48593  | 51.58     | 1.37   |
| 48602  | 50.97     | 0.83   |
| 48624  | 50.60     | 0.97   |
| 48631  | 49.55     | 0.96   |
| 48642  | 48.46     | 0.62   |
| 48648  | 47.83     | 1.02   |
| 48661  | 49.24     | 1.11   |
| 48681  | 46.72     | 0.80   |
| 48721  | 44.19     | 1.30   |
| 48728  | 45.83     | 0.76   |
| 48737  | 43.00     | 0.78   |
| 48745  | 43.46     | 1.13   |
| 48780  | 42.67     | 1.76   |
| 48800  | 43.00     | 1.52   |
| 48805  | 42.99     | 1.87   |
| 48812  | 45.29     | 1.93   |
Table 3e—Continued

| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 48825 | 42.15     | 0.88   |
| 48830 | 41.99     | 1.99   |
| 48863 | 42.69     | 1.02   |
| 48917 | 40.66     | 0.67   |
| 48927 | 41.32     | 1.12   |
| 48967 | 42.06     | 0.70   |
| 48977 | 40.46     | 0.68   |
| 48985 | 40.33     | 0.83   |
| 48993 | 40.69     | 0.78   |
| 49026 | 37.53     | 0.98   |
| 49041 | 36.80     | 0.60   |
| 49051 | 36.25     | 0.66   |
| 49058 | 35.06     | 0.82   |
| 49098 | 33.68     | 0.64   |
| 49107 | 35.35     | 1.09   |
| 49118 | 36.38     | 1.08   |
| 49125 | 34.86     | 1.12   |
| 49134 | 34.74     | 0.61   |
| 49172 | 37.17     | 1.08   |
| 49178 | 37.80     | 1.61   |
| 49199 | 37.62     | 1.09   |
| 49211 | 34.56     | 1.09   |
| 49224 | 35.40     | 1.57   |
| 49284 | 39.18     | 1.46   |
| 49293 | 38.50     | 0.50   |
| 49301 | 40.94     | 0.86   |
| 49309 | 40.34     | 0.48   |
| 49322 | 39.36     | 0.49   |
| 49335 | 41.07     | 0.63   |
| 49345 | 40.53     | 0.63   |
| 49423 | 36.84     | 0.49   |
| 49429 | 36.84     | 0.59   |
| 49446 | 33.51     | 0.74   |
| 49643 | 29.56     | 0.65   |
Table 3e—Continued

| MJD | Flux (Jy) | σ (Jy) |
|-----|-----------|---------|
| 49661 | 29.69     | 0.84    |
| 49671 | 30.49     | 0.50    |
| 49678 | 29.96     | 0.65    |
| 49703 | 32.21     | 0.83    |
| 49713 | 30.44     | 0.38    |
| 49722 | 31.31     | 0.40    |
| 49736 | 31.17     | 0.55    |
| 49745 | 30.20     | 0.36    |
| 49753 | 29.58     | 0.63    |
| 49759 | 29.00     | 0.60    |
| 49814 | 27.42     | 0.42    |
| 49825 | 27.14     | 0.58    |
| 49831 | 27.30     | 0.66    |
| 49840 | 27.39     | 0.89    |
Table 3f. 37 GHz light curve for 3C 273 (Teräsranta, Tornikoski, Valtaoja).

| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 48308 | 36.88     | 0.58   |
| 48319 | 37.54     | 0.91   |
| 48343 | 39.71     | 0.41   |
| 48350 | 39.96     | 0.66   |
| 48367 | 41.10     | 0.39   |
| 48373 | 42.48     | 0.65   |
| 48389 | 44.07     | 0.67   |
| 48402 | 46.53     | 0.95   |
| 48413 | 47.27     | 0.60   |
| 48420 | 47.03     | 0.94   |
| 48437 | 46.23     | 0.77   |
| 48450 | 47.77     | 0.57   |
| 48473 | 49.33     | 0.89   |
| 48493 | 55.70     | 0.62   |
| 48500 | 54.27     | 1.34   |
| 48555 | 49.64     | 0.77   |
| 48573 | 45.40     | 0.99   |
| 48581 | 44.83     | 1.03   |
| 48590 | 49.58     | 1.03   |
| 48607 | 45.78     | 0.94   |
| 48627 | 42.59     | 0.91   |
| 48642 | 42.05     | 0.51   |
| 48652 | 41.48     | 0.50   |
| 48665 | 41.00     | 0.86   |
| 48673 | 40.21     | 0.83   |
| 48722 | 37.57     | 0.53   |
| 48733 | 37.24     | 0.48   |
| 48741 | 37.44     | 0.65   |
| 48745 | 38.21     | 0.85   |
| 48777 | 36.42     | 0.38   |
| 48796 | 37.14     | 0.60   |
Table 3f—Continued

| MJD | Flux (Jy) | σ (Jy) |
|-----|-----------|--------|
| 48801 | 36.87 | 0.80 |
| 48817 | 36.60 | 0.49 |
| 48826 | 36.06 | 0.61 |
| 48868 | 35.56 | 0.52 |
| 48914 | 34.56 | 0.78 |
| 48924 | 33.45 | 0.44 |
| 48977 | 32.03 | 0.78 |
| 48985 | 31.76 | 0.38 |
| 48993 | 32.01 | 0.40 |
| 49026 | 28.95 | 0.40 |
| 49031 | 29.45 | 0.72 |
| 49043 | 27.23 | 0.52 |
| 49047 | 28.32 | 0.61 |
| 49057 | 27.73 | 0.43 |
| 49064 | 27.51 | 0.41 |
| 49096 | 26.64 | 0.46 |
| 49104 | 26.96 | 0.37 |
| 49112 | 27.13 | 0.55 |
| 49119 | 27.25 | 0.44 |
| 49129 | 28.78 | 0.43 |
| 49134 | 29.37 | 0.63 |
| 49164 | 28.45 | 0.36 |
| 49172 | 27.69 | 0.66 |
| 49201 | 29.29 | 0.38 |
| 49211 | 30.92 | 0.51 |
| 49216 | 30.85 | 0.75 |
| 49225 | 29.56 | 0.75 |
| 49288 | 32.59 | 0.55 |
| 49295 | 31.82 | 0.89 |
| 49306 | 31.98 | 0.60 |
| 49314 | 30.91 | 0.78 |
| 49329 | 32.21 | 0.66 |
| 49346 | 31.41 | 0.52 |
| 49360 | 32.21 | 0.77 |
Table 3f—Continued

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 49385| 30.29     | 0.80   |
| 49433| 27.36     | 0.68   |
| 49445| 26.16     | 0.42   |
| 49646| 23.59     | 0.53   |
| 49664| 25.22     | 1.17   |
| 49677| 24.41     | 0.40   |
| 49712| 24.83     | 0.51   |
| 49721| 25.80     | 0.71   |
| 49734| 24.92     | 0.55   |
| 49748| 23.44     | 0.57   |
| 49758| 23.30     | 0.30   |
| 49823| 21.18     | 0.46   |
| 49832| 20.47     | 0.55   |
| 49838| 21.36     | 0.47   |
Table 4a. 0.45 mm fluxes of 3C 273 (McHardy).

\begin{table}[h]
\centering
\begin{tabular}{ccc}
\hline
MJD & Flux & $\sigma$ \\
    & (Jy) & (Jy) \\
\hline
49137 & 5.70 & 1.00 \\
49139 & 5.20 & 1.00 \\
49140 & 6.80 & 1.00 \\
49166 & 5.80 & 1.20 \\
49214 & 3.60 & 1.00 \\
49342 & 3.00 & 0.50 \\
49344 & 3.90 & 1.00 \\
49347 & 2.90 & 0.60 \\
49409 & 3.80 & 0.60 \\
49413 & 4.00 & 0.80 \\
\hline
\end{tabular}
\end{table}
Table 4b. 0.8 mm fluxes of 3C 273 (McHardy).

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 49118| 12.20     | 1.50   |
| 49118| 10.70     | 1.20   |
| 49119| 8.80      | 1.70   |
| 49137| 10.50     | 1.20   |
| 49139| 11.70     | 1.20   |
| 49140| 11.30     | 1.00   |
| 49161| 8.20      | 0.60   |
| 49166| 10.50     | 0.50   |
| 49214| 9.70      | 0.70   |
| 49310| 6.70      | 0.50   |
| 49311| 7.00      | 0.50   |
| 49311| 6.90      | 0.50   |
| 49312| 6.90      | 0.50   |
| 49342| 7.00      | 0.50   |
| 49343| 7.10      | 0.50   |
| 49344| 6.80      | 0.50   |
| 49347| 6.90      | 0.40   |
| 49352| 7.90      | 0.50   |
| 49353| 7.00      | 0.50   |
| 49361| 7.20      | 0.60   |
| 49409| 7.70      | 0.50   |
| 49413| 8.00      | 0.60   |
| 49422| 9.00      | 0.50   |
| 49437| 8.90      | 0.90   |
| 49450| 8.30      | 0.60   |
| 49453| 10.00     | 0.70   |
| 49465| 7.80      | 0.50   |
| 49473| 8.80      | 0.80   |
Table 4c. 1.1 mm fluxes of 3C 273 (McHardy).

| MJD | Flux (Jy) | σ (Jy) |
|-----|-----------|--------|
| 49118 | 14.20     | 1.00   |
| 49118 | 14.10     | 1.00   |
| 49119 | 14.50     | 0.90   |
| 49123 | 14.70     | 1.00   |
| 49137 | 14.00     | 0.80   |
| 49139 | 14.80     | 0.80   |
| 49140 | 14.10     | 0.70   |
| 49161 | 11.80     | 1.00   |
| 49166 | 14.40     | 0.90   |
| 49183 | 16.74     | 1.50   |
| 49187 | 14.60     | 0.50   |
| 49214 | 12.60     | 0.80   |
| 49310 | 9.80      | 0.40   |
| 49311 | 10.00     | 0.60   |
| 49311 | 9.70      | 0.50   |
| 49312 | 9.40      | 0.50   |
| 49314 | 10.20     | 0.60   |
| 49315 | 10.10     | 0.50   |
| 49316 | 10.50     | 0.50   |
| 49318 | 10.20     | 0.40   |
| 49319 | 10.20     | 0.50   |
| 49320 | 10.10     | 0.90   |
| 49326 | 9.90      | 0.60   |
| 49329 | 10.20     | 0.70   |
| 49342 | 9.40      | 0.50   |
| 49343 | 9.80      | 0.50   |
| 49344 | 9.60      | 0.50   |
| 49347 | 9.90      | 0.50   |
| 49348 | 10.10     | 0.60   |
| 49349 | 10.20     | 0.70   |
| 49350 | 10.40     | 0.70   |
| 49351 | 10.80     | 0.60   |
| 49352 | 10.50     | 0.60   |
| 49353 | 10.30     | 0.50   |
Table 4c—Continued

| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 49354 | 10.50     | 0.70   |
| 49355 | 10.50     | 0.50   |
| 49356 | 11.20     | 0.90   |
| 49357 | 11.30     | 0.80   |
| 49358 | 11.30     | 0.80   |
| 49359 | 11.30     | 0.70   |
| 49360 | 10.50     | 0.70   |
| 49361 | 10.30     | 0.60   |
| 49409 | 10.90     | 0.70   |
| 49413 | 10.50     | 0.70   |
| 49422 | 11.00     | 0.40   |
| 49437 | 10.80     | 0.80   |
| 49450 | 10.80     | 0.50   |
| 49453 | 12.10     | 0.70   |
| 49465 | 10.40     | 0.60   |
| 49472 | 10.10     | 0.60   |
| 49473 | 10.70     | 0.60   |
| 49474 | 10.70     | 0.60   |
Table 4d. 1.3 mm fluxes of 3C 273 (Tornikoski, Teräsranta, Valtaoja, Marscher, McHardy, Robson).

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 48269| 12.40     | 0.70   |
| 48300| 17.60     | 1.10   |
| 48340| 19.15     | 0.24   |
| 48341| 18.13     | 0.10   |
| 48342| 18.27     | 0.08   |
| 48351| 22.26     | 1.60   |
| 48353| 18.43     | 0.10   |
| 48353| 18.47     | 0.09   |
| 48354| 18.30     | 0.40   |
| 48354| 18.51     | 0.06   |
| 48366| 19.25     | 0.80   |
| 48393| 17.96     | 0.90   |
| 48417| 18.16     | 0.90   |
| 48441| 13.38     | 1.03   |
| 48454| 17.65     | 0.80   |
| 48480| 20.60     | 1.20   |
| 48493| 20.60     | 1.00   |
| 48514| 19.60     | 1.00   |
| 48530| 16.00     | 0.10   |
| 48533| 15.10     | 0.10   |
| 48559| 15.47     | 0.04   |
| 48571| 14.53     | 0.19   |
| 48589| 17.44     | 0.80   |
| 48607| 16.90     | 0.07   |
| 48653| 13.90     | 0.80   |
| 48654| 12.60     | 1.00   |
| 48668| 13.50     | 1.00   |
| 48697| 14.60     | 0.90   |
| 48710| 15.00     | 1.50   |
| 48714| 13.60     | 1.20   |
| 48727| 14.30     | 1.00   |
| 48749| 13.50     | 0.40   |
| 48776| 10.92     | 0.29   |
| 48777| 11.49     | 0.48   |
| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 48858 | 12.50     | 0.88   |
| 49012 | 10.10     | 0.50   |
| 49025 | 13.70     | 0.70   |
| 49030 | 12.90     | 1.00   |
| 49031 | 13.20     | 1.40   |
| 49032 | 13.00     | 1.00   |
| 49044 | 14.32     | 0.57   |
| 49045 | 15.50     | 1.10   |
| 49046 | 15.27     | 0.58   |
| 49057 | 13.80     | 1.00   |
| 49082 | 16.90     | 0.50   |
| 49093 | 16.90     | 0.90   |
| 49094 | 16.00     | 0.90   |
| 49118 | 15.20     | 1.00   |
| 49118 | 16.20     | 1.00   |
| 49119 | 13.00     | 1.50   |
| 49137 | 15.20     | 0.80   |
| 49139 | 15.90     | 0.80   |
| 49140 | 15.40     | 0.80   |
| 49157 | 14.55     | 0.82   |
| 49166 | 14.90     | 0.80   |
| 49214 | 13.30     | 0.70   |
| 49312 | 11.50     | 0.80   |
| 49315 | 10.90     | 0.60   |
| 49322 | 12.18     | 0.41   |
| 49342 | 10.10     | 0.60   |
| 49343 | 10.30     | 0.50   |
| 49344 | 10.20     | 0.50   |
| 49347 | 10.40     | 0.60   |
| 49352 | 10.60     | 0.60   |
| 49353 | 10.80     | 0.50   |
| 49354 | 11.30     | 0.80   |
| 49360 | 11.10     | 0.80   |
| 49361 | 10.60     | 0.60   |
| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 49409 | 11.20     | 0.70   |
| 49413 | 12.30     | 0.90   |
| 49422 | 11.80     | 0.50   |
| 49453 | 13.10     | 0.80   |
| 49465 | 11.40     | 0.70   |
| 49472 | 10.30     | 0.60   |
| 49473 | 11.30     | 1.00   |
| 49474 | 11.00     | 0.90   |
| 49527 | 13.95     | 0.98   |
| 49527 | 13.99     | 0.98   |
| 49528 | 14.10     | 1.00   |
| 49528 | 14.97     | 1.05   |
| 49775 | 9.53      | 0.77   |
| 49775 | 10.37     | 0.83   |
Table 4e. 2.0 mm fluxes of 3C 273 (McHardy).

| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 49118 | 22.60     | 1.70   |
| 49118 | 20.90     | 1.50   |
| 49119 | 20.70     | 1.20   |
| 49137 | 19.60     | 1.00   |
| 49139 | 19.70     | 1.00   |
| 49140 | 20.20     | 1.00   |
| 49166 | 18.90     | 1.00   |
| 49214 | 18.20     | 0.50   |
| 49310 | 15.30     | 1.10   |
| 49311 | 15.70     | 1.10   |
| 49312 | 15.10     | 0.70   |
| 49314 | 15.70     | 1.00   |
| 49315 | 15.20     | 0.90   |
| 49316 | 15.00     | 0.80   |
| 49318 | 15.20     | 0.90   |
| 49319 | 15.20     | 0.90   |
| 49326 | 14.60     | 0.80   |
| 49329 | 15.70     | 1.20   |
| 49342 | 14.40     | 0.80   |
| 49343 | 14.30     | 0.80   |
| 49344 | 14.30     | 0.80   |
| 49347 | 14.40     | 0.90   |
| 49348 | 14.20     | 0.70   |
| 49349 | 14.60     | 1.00   |
| 49350 | 15.40     | 1.10   |
| 49351 | 15.30     | 1.00   |
| 49352 | 15.10     | 0.90   |
| 49353 | 15.20     | 0.80   |
| 49354 | 15.20     | 1.00   |
| 49355 | 15.10     | 0.80   |
| 49356 | 15.40     | 1.20   |
| 49357 | 15.70     | 1.10   |
| 49358 | 15.50     | 1.00   |
| 49359 | 15.10     | 0.90   |
Table 4e—Continued

| MJD   | Flux (Jy) | σ (Jy) |
|-------|-----------|--------|
| 49360 | 15.20     | 1.00   |
| 49361 | 14.90     | 1.00   |
| 49409 | 14.00     | 0.80   |
| 49413 | 13.40     | 0.90   |
| 49422 | 15.10     | 0.70   |
| 49450 | 13.70     | 1.00   |
| 49453 | 17.00     | 1.00   |
| 49474 | 14.80     | 1.50   |
Table 4f. 3.0 mm fluxes of 3C 273 (Tornikoski, Teräsranta, Valtaoja).

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 47896| 16.96     | 0.69   |
| 47931| 14.89     | 0.60   |
| 47937| 15.61     | 0.63   |
| 47951| 15.78     | 0.63   |
| 47966| 14.53     | 0.58   |
| 47981| 12.84     | 0.52   |
| 47988| 13.26     | 0.53   |
| 47989| 13.47     | 0.54   |
| 47994| 14.11     | 0.57   |
| 47995| 13.94     | 0.56   |
| 47996| 13.85     | 0.56   |
| 47997| 14.27     | 0.57   |
| 47998| 14.44     | 0.58   |
| 48004| 14.23     | 0.57   |
| 48011| 15.26     | 0.61   |
| 48022| 17.76     | 0.71   |
| 48053| 28.11     | 1.14   |
| 48062| 29.61     | 1.19   |
| 48071| 32.38     | 1.30   |
| 48104| 33.49     | 1.35   |
| 48231| 29.17     | 1.20   |
| 48256| 25.31     | 1.08   |
| 48314| 32.23     | 1.29   |
| 48351| 36.22     | 1.46   |
| 48430| 33.86     | 1.36   |
| 48455| 34.93     | 1.40   |
| 48469| 36.10     | 1.50   |
| 48591| 29.98     | 1.20   |
| 48592| 29.70     | 1.19   |
| 48614| 27.13     | 1.09   |
| 48615| 26.61     | 1.07   |
| 48664| 29.47     | 1.19   |
| 48665| 28.03     | 1.12   |
| 48726| 28.10     | 1.13   |
Table 4f—Continued

| MJD  | Flux (Jy) | σ (Jy) |
|------|-----------|--------|
| 48785| 25.38     | 1.02   |
| 48857| 25.21     | 1.01   |
| 48987| 18.28     | 0.75   |
| 49043| 21.80     | 0.88   |
| 49078| 26.30     | 1.05   |
| 49139| 28.57     | 1.14   |
| 49155| 23.43     | 0.94   |
| 49323| 23.13     | 0.93   |
| 49326| 22.51     | 0.90   |
| 49326| 23.64     | 0.95   |
| 49350| 23.37     | 0.94   |
| 49384| 20.70     | 0.83   |
| 49384| 22.41     | 0.90   |
| 49385| 20.62     | 0.83   |
| 49385| 23.15     | 0.93   |
| 49466| 19.91     | 0.81   |
| 49467| 20.14     | 0.81   |
| 49504| 20.25     | 0.82   |
| 49528| 21.97     | 0.88   |
| 49565| 21.38     | 0.86   |
| 49698| 22.03     | 0.89   |
| 49699| 21.01     | 0.96   |
| 49749| 18.10     | 0.73   |
| 49776| 16.50     | 0.66   |
| 49776| 16.94     | 0.68   |
Table 5. Summary of IR and optical observations of 3C 273 (Courvoisier, Marscher, Robson, Wagner).

| MJD  | Flux (mJy) | σ (mJy) | Flux (mJy) | σ (mJy) | Flux (mJy) | σ (mJy) | Flux (mJy) | σ (mJy) | Flux (mJy) | σ (mJy) | Flux (mJy) | σ (mJy) | Flux (mJy) | σ (mJy) | Flux (mJy) |
|------|------------|---------|------------|---------|------------|---------|------------|---------|------------|---------|------------|---------|------------|---------|------------|
| 49078 | · · · · · ·            | 30.34  | 1.37          | 30.76  | 1.38          | 29.24  | 1.32          | 34.51  | 1.55          | · · · · · ·          |            |
| 49304 | · · · · · ·            | · · · · · ·          | 26.67  | 0.49          | · · · · · ·          |            |
| 49310 | · · · · · ·            | · · · · · ·          | 26.92  | 0.49          | · · · · · ·          |            |
| 49330 | · · · · · ·          | · · · · · ·          | · · · · · ·          | 38.02  | 1.71          | 50.82  | 2.29          | 84.33  | 3.80          | · · · · · ·          |            |
| 49331 | · · · · · ·          | · · · · · ·          | · · · · · ·          | 41.30  | 1.86          | 52.24  | 2.35          | 88.31  | 4.80          | · · · · · ·          |            |
| 49372 | · · · · · ·          | · · · · · ·          | 30.62  | 1.38          | 31.05  | 1.40          | 29.24  | 1.32          | 26.92  | 1.21          | · · · · · ·          |            |
| 49386 | 31.14  | 0.28          | 30.37  | 0.20          | 33.18  | 0.19          | · · · · · ·          |            |
| 49398 | · · · · · ·          | · · · · · ·          | 27.42  | 0.50          | · · · · · ·          |            |
| 49399 | 31.98  | 0.28          | 31.48  | 0.20          | 33.89  | 0.19          | · · · · · ·          |            |
| 49400 | 32.42  | 0.28          | 31.66  | 0.20          | 33.64  | 0.19          | 27.67  | 0.51          | · · · · · ·          |            |
| 49414 | 33.12  | 0.28          | 32.10  | 0.20          | 34.65  | 0.19          | · · · · · ·          |            |

Table 6. Summary of IUE/EUVE observations of 3C 273 (Kafatos). UV-fluxes are corrected for interstellar absorption using a value for E(B-V) = 0.03 and the reddening law of Seaton (1979).

| MJD  | LWP(1.07×10^{15} Hz) Flux (mJy) | σ (mJy) | SWP(2.14×10^{15} Hz) Flux (mJy) | σ (mJy) | DSS(2.99×10^{16} Hz) Flux (mJy) | σ (mJy) |
|------|----------------------------------|---------|----------------------------------|---------|----------------------------------|---------|
| 49360 | 26.30                           | 0.99    | 13.93                           | 0.48    | · · · · · ·                        | · · ·   |
| 49523 | 27.56                           | 0.99    | 16.36                           | 0.48    | · · · · · ·                        | · · ·   |
| 49360-49366 | · · · · · · | · · · · · · | · · · · · · | · · · · · · | 0.319                           | 0.064   |
| 49720-49729 | 24.84                           | 0.76    | 13.46                           | 0.36    | 0.195                           | 0.039   |
Table 7. ASCA spectra and fluxes of 3C 273 in December 1993 (Makino, Kii).

| Date (MJD) | Focal Plane Instruments | mean frequency (10^{18}Hz) | Flux density (µJy) | Flux (2-10 keV) (10^{-10}erg/cm^{2}s) | Photon Indices (90% error area) |
|------------|-------------------------|-----------------------------|-------------------|--------------------------------------|-------------------------------|
| Dec 16 (49337) | SIS-S0                  | 1.058                        | 9.84              | 1.72                                 | 1.60 (1.59-1.62)              |
|             | SIS-S1                  | 1.056                        | 9.51              | 1.66                                 | 1.61 (1.59-1.62)              |
|             | GIS-S2                  | 1.061                        | 9.30              | 1.63                                 | 1.59 (1.57-1.60)              |
|             | GIS-S3                  | 1.058                        | 9.26              | 1.62                                 | 1.60 (1.58-1.61)              |
| Dec 19 (49340) | SIS-S0                  | 1.065                        | 8.63              | 1.52                                 | 1.57 (1.56-1.58)              |
|             | SIS-S1                  | 1.061                        | 8.39              | 1.47                                 | 1.59 (1.58-1.60)              |
|             | GIS-S2                  | 1.067                        | 7.59              | 1.34                                 | 1.56 (1.55-1.58)              |
|             | GIS-S3                  | 1.067                        | 7.70              | 1.36                                 | 1.56 (1.55-1.57)              |
| Dec 20 (49341) | SIS-S0                  | 1.058                        | 8.12              | 1.42                                 | 1.60 (1.59-1.62)              |
|             | SIS-S1                  | 1.061                        | 7.93              | 1.39                                 | 1.59 (1.57-1.61)              |
|             | GIS-S2                  | 1.061                        | 7.19              | 1.26                                 | 1.59 (1.57-1.61)              |
|             | GIS-S3                  | 1.063                        | 7.17              | 1.26                                 | 1.58 (1.56-1.59)              |
| Dec 23 (49344) | SIS-S0                  | 1.065                        | 8.40              | 1.48                                 | 1.57 (1.56-1.59)              |
|             | SIS-S1                  | 1.067                        | 8.33              | 1.47                                 | 1.56 (1.55-1.58)              |
|             | GIS-S2                  | 1.069                        | 7.57              | 1.34                                 | 1.55 (1.53-1.57)              |
|             | GIS-S3                  | 1.069                        | 7.57              | 1.34                                 | 1.55 (1.53-1.56)              |
| Dec 27 (49348) | SIS-S0                  | 1.074                        | 10.30             | 1.83                                 | 1.53 (1.52-1.55)              |
|             | SIS-S1                  | 1.079                        | 10.42             | 1.86                                 | 1.51 (1.49-1.52)              |
|             | GIS-S2                  | 1.081                        | 9.17              | 1.64                                 | 1.50 (1.49-1.52)              |
|             | GIS-S3                  | 1.079                        | 9.19              | 1.64                                 | 1.51 (1.49-1.53)              |
Table 8. OSSE spectrum of 3C 273 during MJD 49341-49348 (Johnson).

| mean frequency (Hz) | Flux (µJy) | σ (µJy) |
|---------------------|------------|---------|
| $2.1 \cdot 10^{19}$ | 1.40       | 0.14    |
| $5.1 \cdot 10^{19}$ | 0.76       | 0.16    |
| $1.2 \cdot 10^{20}$ | 0.13       | 0.19    |
| $2.6 \cdot 10^{20}$ | 0.48       | 0.35    |
| $5.9 \cdot 10^{20}$ | 0.00       | 0.22    |
| $1.5 \cdot 10^{21}$ | 0.11       | 0.10    |

Table 9. COMPTEL spectrum of 3C 273 during MJD 49279-49355 (Collmar).

| mean frequency (Hz) | Flux (µJy) | σ (µJy) |
|---------------------|------------|---------|
| $2.1 \cdot 10^{20}$ | 0.12       | 0.077   |
| $4.0 \cdot 10^{20}$ | 0.097      | 0.023   |
| $1.2 \cdot 10^{21}$ | 0.036      | 0.0082  |
| $4.0 \cdot 10^{21}$ | < 0.0078   |         |