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The 0716+714 WEBT campaign of February 1999

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Abstract. In February 1999, the Whole Earth Blazar Telescope (WEBT) organization carried out an optical campaign on the blazar S5 0716+71. This campaign had two principal aims: to test the potential of such an optical telescope network devoted to the study of blazar variability and to search for possible time delays between variations in different optical bands. The main results of this campaign are presented here. The six participating observatories collected a large amount of optical data in $UBVRI$ bands: 635 observations were performed in the observing period from February 16.0 to 19.0, forming the densest dataset ever obtained for a blazar during a 72-hour period. Besides constructing continuous and dense optical light curves, this monitoring effort has provided some very significant results. On one hand, we have determined the steepest recurrent variation slope to be $0.002\ \mathrm{mag}$ per minute, on both rising and decreasing phases, thus constraining the properties of the emitting region. On the other hand, an upper limit to the possible delay between B and I variations (10 minutes) has been fixed thanks to the high quality and density of part of the dataset. Moreover, in a comparison with previous data, we have discovered a long-term trend of the spectral index, implying a steepening of the optical spectra and a shift of the synchrotron peak towards the infrared during the last five years.

Key words: galaxies: active – galaxies: BL Lacertae objects: general – galaxies: BL Lacertae objects: individual: S5 0716+71 – galaxies: quasars: general

1. Introduction

As is well known, the celestial objects called blazars are a special class of active galactic nuclei (AGNs) presenting extreme properties like huge and exceptionally variable emission in all the electromagnetic bands, from radio to γ-rays (in some cases up to TeV energies). This coexistence of very large luminosity and very strong variability (plus other observed features like superluminal motion of parsec-scale radio-emitting structures) led astronomers to the conclusion that such emission could not be isotropic, but that the emitting material must be organized in a relativistic magnetized jet with bulk Lorentz factor ~ 10 and that it consists of highly-relativistic synchrotron-emitting particles.

The source of the large kinetic and luminous energies involved is unknown, but it is believed that its origin can be found in the gravitational and rotational energies of some supermassive black hole(s) present at the base of the jet, in the gravity centre of the host galaxy. How this energy can be produced and transformed into what we observe is the mystery that fascinates blazar (and AGN) researchers.

While a large international collaboration devoted to the long-term optical variability study of blazars already existed (the OJ-94 Project, in particular collecting data for confirming the periodic behaviour of the BL Lac object OJ 287), astronomers realized that the voluntary effort of the various optical observers sporadically intent on the optical coverage of satellite pointings could be made much more efficient if coherently organized.

The Whole Earth Blazar Telescope (WEBT) collaboration was born to this aim (e.g. Mattox 1999a, 1999b). Its main purpose is the coordination of the blazar observing activity of about twenty optical observatories around the world during blazar multiwavelength campaigns. Because of the longitude diversity of participating observatories, the collaboration can provide continuous optical monitoring, using telescopes in the east to west direction as the Earth rotates. With a sufficient number of observatories to compensate for inclement weather, the result can be a high-temporal-density and continuous optical light curve.

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One of the main WEBT goals is the recruitment of more observers from a wide range of locations. Moreover, WEBT members are planning (and in some case executing) an Automatic Telescope Network (ATN; Mattox 1999c; Tosti 1999; Delbò et al. 1999) in view of the new-generation orbiting telescopes likely to observe blazars at high energies, such as GLAST, AGILE, XMM-Newton, Chandra, INTEGRAL, etc.. Indeed, it is expected that these new space facilities will require such a huge amount of simultaneous optical monitoring that only a dedicated network of automatic telescopes can provide.

Another topic of great interest that can be investigated through the WEBT collaboration is the study of correlation between optical and radio intraday variability (IDV; see e.g. Quirrenbach et al. 1991; Wagner et al. 1996). To clarify this issue, the WEBT collaboration organized a 1-month campaign in March 2000 of simultaneous and continuous radio–optical monitoring of 0716+714 (and other selected IDV sources), the results of which will be described in a subsequent paper.

Moreover, according to the inhomogeneous jet models, time delays are expected between the emission in different energy bands, as plasma disturbances propagate downstream. Indeed, lags have been detected between, e.g., X-ray and UV band (see e.g. Georganopoulos & Marscher 1998 and references therein for the case of PKS 2155−304). It is thus very interesting to search for detectable delays between optical bands themselves, even if these can be expected to be very small, if any.

In this paper we present the results of a "trial" optical campaign on S5 0716+71 performed in February 1999. After a quick presentation of the source in Sect. 2, the observation and data reduction information is presented in Sect. 3; Sect. 4 contains the campaign results, while the conclusions are drawn in Sect. 5.

2. S5 0716+71

0716+714 was discovered in 1979 in the ambit of the Bonn-NRAO radio survey and is part of the S5 catalogue subsample having flat radio spectra and $5\,\mathrm{GHz}$ flux greater than $1\,\mathrm{Jy}$ (Kühr et al. 1981, 1987; Witzel et al. 1988). Because of its featureless spectrum and its strong optical polarization, it was classified as a BL Lac object by Biermann et al. (1981). No sign of a host galaxy has been found in deep images, apart from a weak galaxy $5\,\mathrm{arcsec}$ south–westward, spatially distinct from the source (Stickel et al. 1993; Wagner et al. 1996). From its stellar appearance Stickel et al. (1993) derived a redshift lower limit $z > 0.2$, whereas Schalinski et al. (1992) give $z > 0.3$. By comparison with nearby galaxies of known redshift ($z \approx 0.26$; Stickel et al. 1993), Wagner et al. (1996) assume $z > 0.3$, which would be the lower limit for a host galaxy as faint as $M_{\rm gal} = -20.4$.

On arcsecond scales, radio images reveal a core–halo morphology, with an amorphous halo extending up to about $10\,\mathrm{arcsec}$ (Antonucci et al. 1986; see also Perley et al. 1980, 1982; Perley 1982). A jet is visible in the 5 and $8.4\,\mathrm{GHz}$ maps by Wagner et al. (1996), eventually ending in a hot spot, thus resembling an FRII morphology (see also Antonucci et al. 1986). The jet orientation seems to be different (by about $70°$) at the milliarcsecond scale of VLBI maps: 5 and $22\,\mathrm{GHz}$ images show a very compact structure with some evidence of a jet-like elongation (Eckart et al. 1986, 1987; Witzel et al. 1988), confirmed by VLBI and VLBA images taken in 1991 and 1994 (Gabuzda et al. 1998). Proper motion of VLBI components was measured by Schalinski et al. (1992), with an apparent superluminal speed $\beta_{\rm app} = 4.6$ ($z = 0.3$, $H_0 = 50\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$), whereas Gabuzda et al. (1998) found smaller values: $\beta_{\rm app} \sim 2$.

As for the optical observations, uncalibrated data are reported in some papers devoted to variability studies (Quirrenbach et al. 1991; Wagner & Witzel 1995; Heidt & Wagner 1996; Wagner et al. 1996; Otterbein et al. 1998) and a few data are quoted in Perley et al. (1980), Kühr et al. (1981), Biermann et al. (1981), Beskin et al. (1985), Kühr & Schmidt (1990), and Takalo et al. (1994). The first calibrated optical light curve of S5 0716+71 was composed by the monitoring groups from Perugia, Roma, and Torino, which observed the source in $BVRI$ (Johnson–Cousins) around the EGRET pointing of February 1995 (from November 1994 to April 1995; Ghisellini et al. 1997). Updates to this light curve can be found in Villata et al. (1998a), Massaro et al. (1999a), and Raiteri et al. (1999), where the light curve spans five observing seasons (1994–1999) with wide and fast variations in the range $R \sim 12.6$–14.7. Other sources of calibrated optical data are the papers by Sagar et al. (1999) and Giommi et al. (1999). The former presents the results of the dense $BVRI$ monitoring performed in the ambit of a 4-week multifrequency campaign in February–March 1994; the latter contains the results of coordinated BeppoSAX and optical observations performed in 1996 and 1998.

A compilation of optical (and multifrequency) data on S5 0716+71, together with a study of its spectral properties, is in preparation (Villata et al. 2000a).

Photometric sequences for the 0716+714 field can be found in Takalo et al. (1994), Ghisellini et al. (1997), and Villata et al. (1998b).

3. Observations and data reduction

The WEBT campaign of February 1999 was started with the participation of six observatories with the aim of monitoring 0716+714 for 72 hours during February 16–18 (UT).

Primary goals were to obtain as continuous as possible high-precision light curves in two optical bands (B–R or B–I) in order to examine the possible existence of a lag between their variations, and to test the efficiency of such a network, in view of the radio–optical campaign of March 2000.

Table 1 shows the participating observatories and the number of data points provided in the various bands, during the extended period February 15–22. The number of data shown there corresponds more or less to the number of individual observations (about 1% of the observations has been discarded as not reliable or too uncertain), with the exception of KVA R-band data, which come from a series of 76 short-exposure (1–2 minutes) observations with large uncertainties, binned into 8 data with smaller errors.

Table 1. Observatories participating to the campaign

Observatory	Telescope	Size (cm)	N_U	N_B	N_V	N_R	N_I
Catania, Italy (CT)	Fracastoro	91	84	83	–	–	–
KVA, La Palma (KV)		20	–	–	–	8	–
Lowell, Arizona (LO)	Perkins	180	–	163	3	68	108
Perugia, Italy (PG)	AIT	40	–	–	–	44	–
Torino, Italy (TO)	REOSC	105	–	20	9	38	–
Vallinfreda, Italy (VA)		50	–	–	–	–	198
Total			84	266	12	158	306

Apart from the photometer observations (Johnson's U, B filters) of the Catania Observatory (see e.g. Massaro et al. 1999b), all the other observations were performed with CCD cameras in the standard (Johnson–Cousins) $BVRI$ bands. Typical separations between consecutive photometer observations were around 9 minutes; integration times for CCD frames varied by filter and observatory. In I-band 0.5 minutes were typically used at Lowell and 2–3 minutes at Vallinfreda. R and V observations were carried out with typical exposures of ~ 0.5 (LO) and 4–5 minutes (PG, TO), while B-band frames were usually integrated for 5 minutes at Lowell and 7 minutes at Torino. Readout times ranged from less than 1 (LO) to ~ 3 minutes (TO), so that, when performing alternate observations in two bands, the time resolution of each light curve was about 7 minutes for the B–I sequence from Lowell and about 17 minutes for B–R from Torino.

After flat-fielding and bias/dark corrections, aperture photometry (or Gaussian fitting for Torino frames) was performed on CCD frames by the various observers themselves. Data were then collected as instrumental magnitudes of the source and comparison stars, in order to apply the same analysis procedure and calibration to all datasets. To this end the differential magnitudes were calculated with respect to two reference stars only, namely those that were present in all frames. These are Stars 5 and 6 in the finding chart by Villata et al. (1998b; i.e. the stars $1.26\,\mathrm{arcmin}$ south and $1.66\,\mathrm{arcmin}$ NE of 0716+714); their BVR standard magnitudes were taken from that paper, whereas the I-band calibration was performed according to the values reported by Ghisellini et al. (1997).

Because of different longitudes, filters used, and weather conditions of participating observatories, there is almost no overlap among the various datasets. In the few cases where simultaneous data allow a comparison between different telescopes, a good consistency was found. Only the photometer B data were found to be systematically brighter than CCD data, so that they were scaled by $0.1\,\mathrm{mag}$.

Problematic differences do appear instead when comparing differential magnitudes between Stars 6 and 5. Table 2 displays the mean values (and standard deviations) obtained at the various sites, compared with those from standard magnitudes. Since the two stars have similar spectra, different CCD–filter systems should not be the cause of such high systematic differences; different, non-linear response of the cameras could instead account for them. Due to the similarity among the magnitudes of 0716+714, Star 5, and Star 6, these discrepancies should not affect the results very much. Unfortunately, the lack of overlap among different datasets prevents further investigation and possible corrections.

Table 2. Differential magnitudes of reference stars

Observatory	ΔB_{6-5}	ΔV_{6-5}	ΔR_{6-5}	ΔI_{6-5}
KVA	–	–	0.10 (0.05)	–
Lowell	0.04 (0.01)	0.06 (0.01)	0.05 (0.01)	0.06 (0.01)
Perugia	–	–	0.16 (0.03)	–
Torino	0.10 (0.02)	0.11 (0.01)	0.08 (0.01)	–
Vallinfreda	–	–	–	0.10 (0.02)
Standard mags	0.09	0.08	0.08	0.12

Besides being the only available common comparison stars, Stars 5 and 6 have the advantage of having magnitudes and spectra similar to those of 0716+714, which simplifies the analysis and allows us to obtain more reliable results.

0716+714 standard magnitudes are derived as the average between the magnitudes obtained from the comparison with Stars 5 and 6. The errors are considered as errors on the intranight variations, disregarding any calibration error, in that we are interested in variations rather than in a precise evaluation of the magnitude. The error is thus taken as the maximum among the following quantities:

– the deviation of the magnitude difference between Stars 5 and 6 of the considered frame from the mean on the intranight dataset;
– the standard deviation of the above quantity;
– the maximum among the errors on the instrumental magnitudes of 0716+714, Stars 5 and 6 in the considered frame;
– a lower limit (usually $0.01\,\mathrm{mag}$).

Exceptions to this procedure are represented by the already mentioned Catania photometer data, for which the standard magnitudes and errors were provided directly by the observers, and by the KVA data described above.

4. Results and discussion

4.1. Light curves

The main results of the above described observations, reduction, data collection, and analysis are shown in Figs. 1 and 2. In the former one can find the light curves in $UBRI$ bands; the V band has been omitted since the low number of data (12) does not add any information on the variation trend, even if they will be useful for the construction of the optical spectrum (see Sect. 4.3).

As can be seen from Fig. 1, the source exhibited strong variability, with similar trend (but different amplitudes) in all bands. The overall variations in $UBRI$ were $\Delta U = 0.94$, $\Delta B = 0.86$, $\Delta R = 0.77$, and $\Delta I = 0.70$, where the differences are mainly due to different sampling. The observatories contributing to the different bands are indicated in the corresponding panels (see also Table 1). The best sampled bands are B and I, where most of the data comes from Lowell and Vallinfreda.

The maximum R-band brightness was recorded on February 19.83 as $R = 12.96$, not so far from the historical maximum (see Raiteri et al. 1999). The most spectacular variation was registered on February 16–17: a brightness rise from $R = 13.68$ to 13.02 in less than 24 hours.

The best-sampled and highest-quality intranight dataset (B and I) is by far that from Lowell on February 18, where the detected strong brightness and colour variations make it worthy of a dedicated figure (Fig. 3). The bottom curve in Fig. 3 shows the variations of the colour index $B - I$ (shifted by $+12.75$): a correlation with brightness can be seen, with some hint for a delay in the colour changes.

We note the monotonic brightness increase from $B = 14.13 \pm 0.01$ to $B = 13.98 \pm 0.01$ in about 130 minutes, with the steepest (linear) part having a rising rate of $0.002\,\mathrm{mag}$ per minute and a duration of about 45 minutes. Similar slopes are also seen in other well-sampled intranight datasets: increasing and decreasing rates of 0.0015–$0.002\,\mathrm{mag}$ per minute with durations of 30–80 minutes can be found on February 16 (I band from Vallinfreda and B, R bands from Lowell) and 18 (I band from Vallinfreda and R band from Torino), so that such a gradient seems to be typical of fast variations, with no evident difference between rise and fall.

The above slopes are quite similar to the values reported by Wagner et al. (1996) as the fastest rising and declining slopes (about 10% per hour) found in their dataset of February 1990. On the other hand, other IDV data reported by Ghisellini et al. (1997) and Sagar et al. (1999) show only slower variations.

Extensive discussions on the implications of rapid variations on models for emission mechanisms and geometries can be found in, e.g., Wagner et al. (1996) and Ghisellini et al. (1997).

Fig. 2 displays the coadded R and I light curves, with I magnitudes properly scaled in order to simulate a single light curve. (Due to significantly different $R-I$ colour indexes from different datasets, I magnitudes from Vallinfreda were scaled by $0.58\,\mathrm{mag}$, as a mean value obtained by comparing PG–TO–VA simultaneous data, whereas an addition of $0.52\,\mathrm{mag}$ was applied to I-band Lowell data, according to their mean colour index.) All fast variations can be seen here in a single look. Another item that is made evident is how this kind of study needs high-quality and dense datasets contributed by large telescopes.

The result of the campaign can be considered as fairly satisfactory, in that it represents the first quasi-successful attempt to monitor a blazar so intensively and continuously for a period of a few days: from February 16.0 to 19.0 (the originally scheduled observing period) 635 useful observations were done, with a rate of about 9 observations per hour, that is the densest dataset ever obtained for a blazar during a 72-hour interval.

4.2. DCF analysis

One of the purposes of this campaign was to examine the possible existence of a lag between variations in different optical bands. We have performed a discrete correlation function (DCF) analysis (see e.g. Edelson & Krolik 1988; Hufnagel & Bregman 1992) on various samples taken from the data collected here. The only dataset that can provide highly reliable results in this sense is that of February 18 from Lowell, shown in Fig. 3, thanks to its high quality (errors $\sim 0.01\,\mathrm{mag}$), density (one B–I pair every $\sim$ 7 minutes, or even less), and presence of strong variations, as seen above.

The results are shown in Figs. 4 and 5. The former displays B–B autocorrelation, which gives information on the adequacy of the data to be analysed in this way, and provides a useful comparison term for the correlation between different bands. In our case, the smooth but well-peaked curve, along with small error bars, gives assurance on the good properties of the dataset. The same behaviour is shown by the autocorrelation in I band.

Similar features are present in the B–I correlation shown in Fig. 5 (upper curve), meaning that the result is highly reliable, even if it does not appear so indicative. Indeed, the possible delay of I-band variations of about 7 minutes shown by the DCF peak is of the same magnitude of the DCF bin size (7.2 minutes) and of the light-curve time resolution, and the peak itself presents some distortion.

In Figs. 4 and 5 (upper curve) are shown the results obtained with no data averaging (since they are already fairly equispaced) and with the above DCF bin size of 0.005 days. Anyway, similar results are obtained with different choices of these parameters, thus suggesting a delay of the I-band emission in the range 0–10 minutes. As an example, the bottom curve in Fig. 5 shows what is obtained (shifted vertically by -0.5 in order to avoid overlap with the previous curve) with a data binning of 5.76 minutes and a DCF bin of 14.4 (0.01 days).

As far as we are aware, this result represents the first strict upper limit to a possible lag between optical bands, even if a small or null delay is what is expected due to the closeness of the two energy bands compared with the multiwavelength output of the source. Indeed, time lags between more separated bands are well known and support the inhomogeneous models for the emitting jet (see e.g. Georganopoulos & Marscher 1998).

The above results have been obtained with a light-curve time resolution of the same magnitude as the possible lag, using a $1.8\,\mathrm{m}$ telescope and exposure times of 300 and $30\,\mathrm{s}$ in B and I band, respectively. Hence, much more significant results can be achieved only with a larger telescope, even if a bit denser data could be obtained by shortening B-band exposures with the same telescope. Using the same type of camera, a 2.5–$3\,\mathrm{m}$ telescope would allow a light-curve time resolution around 4 minutes, whereas more than $5\,\mathrm{m}$ are requested for a resolution

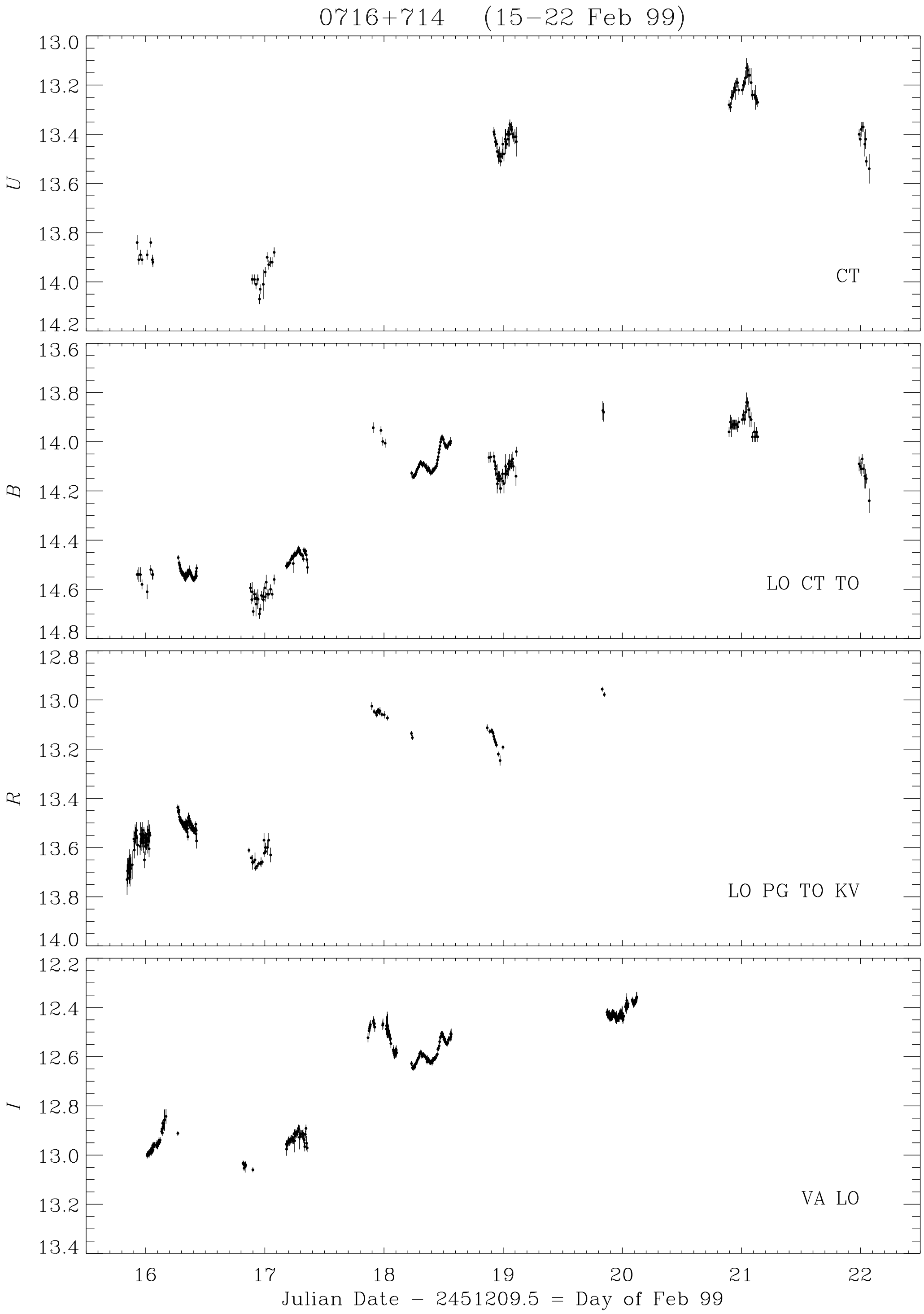

Fig. 1. Light curves of S5 0716+71 in the $UBRI$ bands from February 15 to 22, 1999; the observatories contributing to the various bands are indicated in the corresponding panels (cf. Table 1)

less than 2 minutes. Obviously, the synchronized use of two or more telescopes could greatly improve the situation.

4.3. Spectral properties

Apart from three data found in Beskin et al. (1985) and Takalo et al. (1994), the U-band measurements shown in this paper represent the first dataset in this band. Our average $U-B$ colour index, as computed from the original Catania photometer data (i.e. without applying the $0.1\,\mathrm{mag}$ correction to B magnitudes mentioned in Sect. 3), is $-0.59\,\mathrm{mag}$ ($\sigma = 0.03$), with a slight trend for increasing $U-B$ with decreasing brightness, in agreement with the general behaviour of blazars for which the optical variations are stronger at higher frequencies. Previous $U-B$ values range from -0.62 ± 0.02 to $-0.55 \pm 0.05\,\mathrm{mag}$, quite consistently with ours, so that probably both U and B photome-

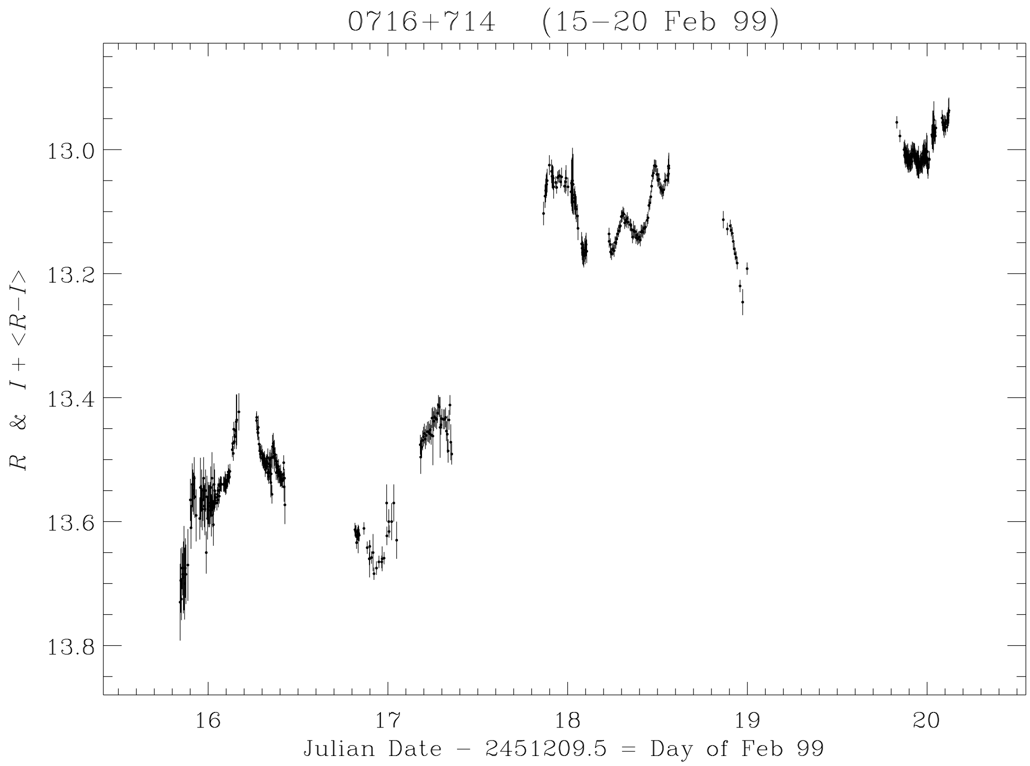

Fig. 2. Light curve of S5 0716+71 in the coadded R and I bands from February 15 to 20, 1999; I-band data have been properly scaled in order to simulate a single light curve

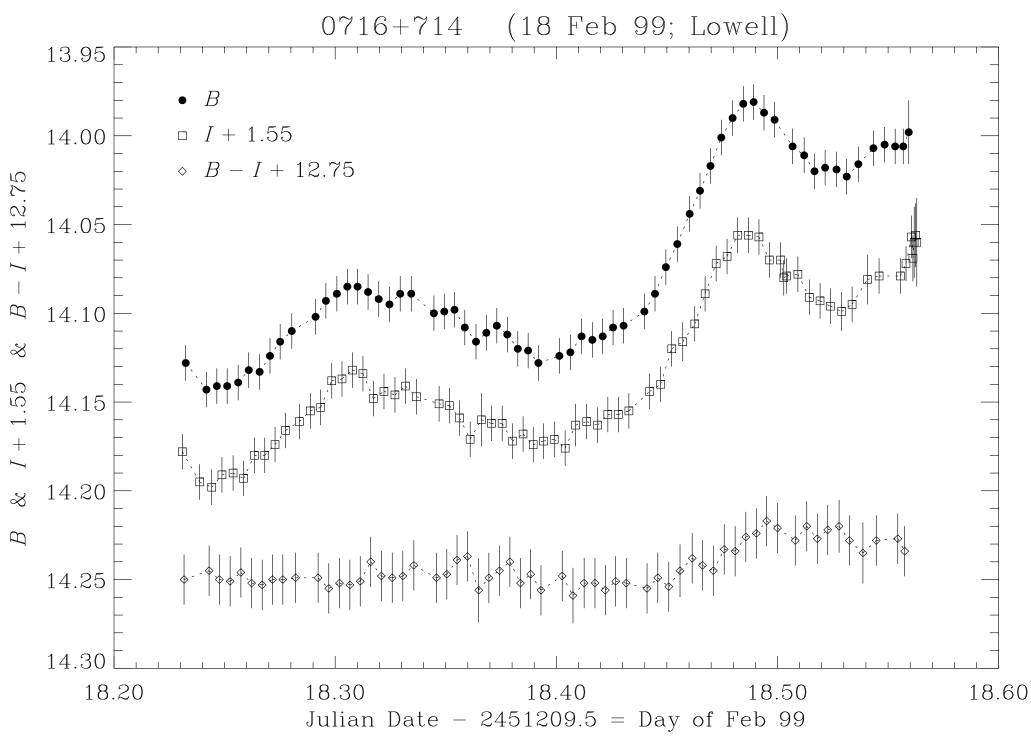

Fig. 3. B and I (+1.55) light curves on February 18.2–18.6 from Lowell Observatory (1.8 m Perkins Telescope); the bottom curve shows the variations of the colour index $B-I$ (+12.75)

ter data would need an offset correction to be compared with CCD data. For homogeneity, in the following spectral study we use only CCD data for $BVRI$ bands, thus limiting the use of photometer data to the U band (without any correction).

In Fig. 6 we show six optical spectra obtained from our dataset on February 16.27 (±0.003), 16.90 (±0.006), 17.91 (±0.007), 18.24 (±0.002), 18.90 (±0.027), and 19.86 (±0.017), thus covering various brightness states where multi-band observations were available. Filled triangles (16.27 and 18.24) represent data from Lowell; in the other spectra, I-band fluxes are from Vallinfreda, RVB ones from Torino, and U from Catania.

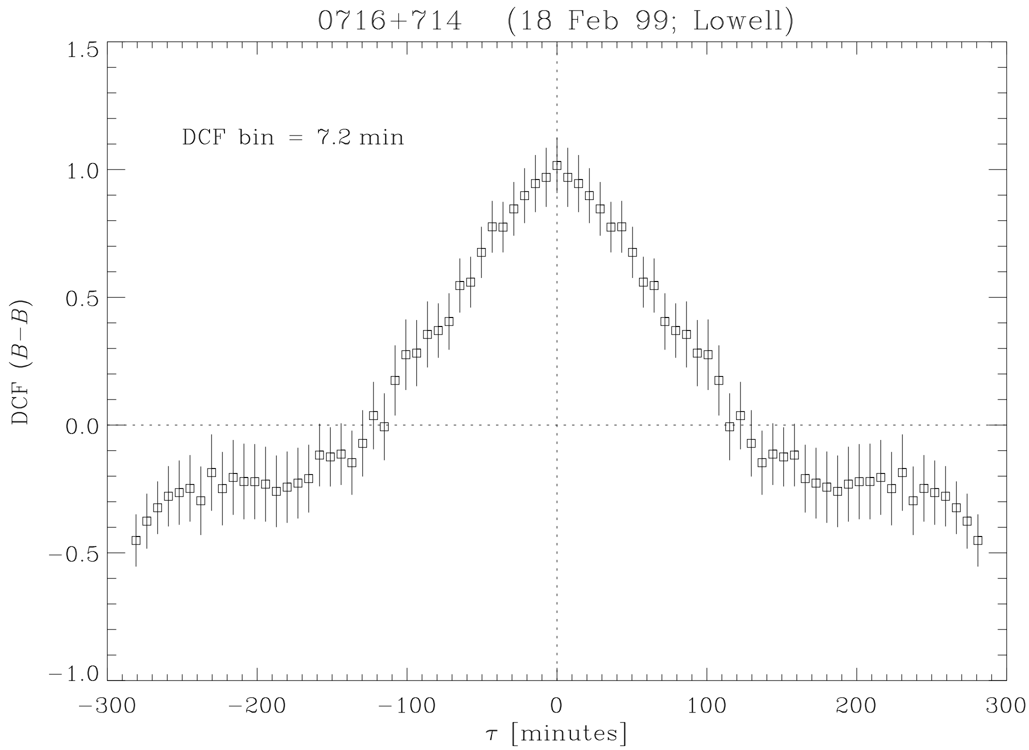

Fig. 4. DCF analysis on the B-band autocorrelation from the data of February 18 shown in Fig. 3; no data binning has been performed and a DCF bin size of 0.005 days has been used

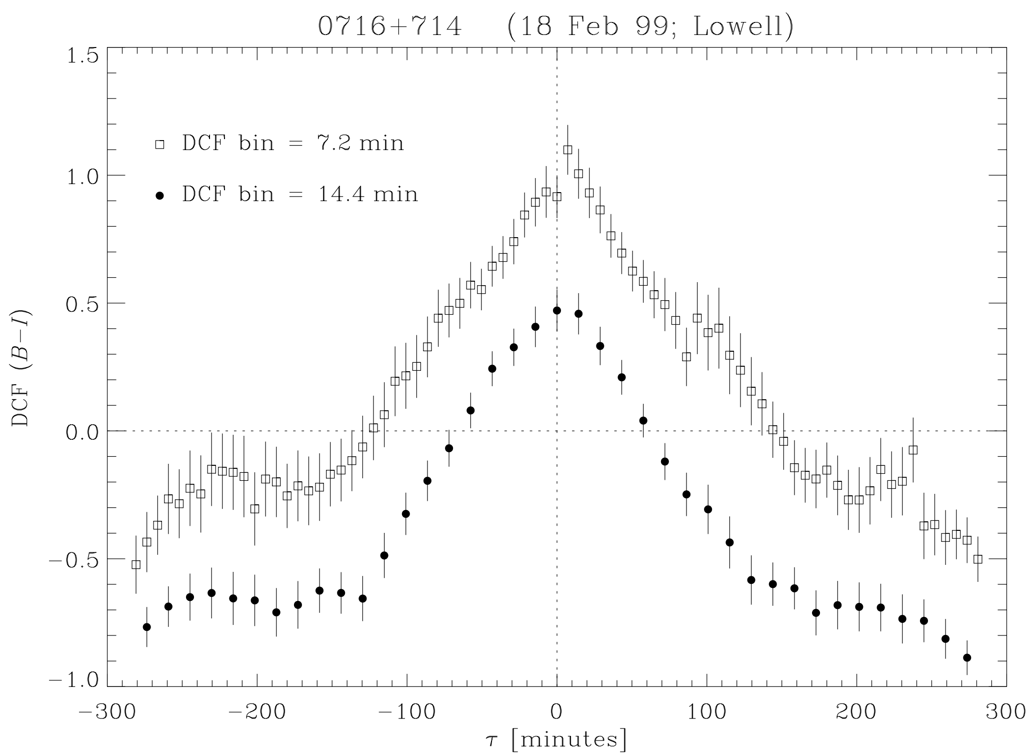

Fig. 5. DCF analysis on the B–I dataset of February 18 from Lowell, shown in Fig. 3; the bottom curve has been shifted vertically by -0.5 for avoiding overlap with the upper curve

Magnitudes have been dereddened by using a Galactic extinction coefficient $A_B = 0.132$ (Schlegel et al. 1998) and following Rieke & Lebofsky (1985) and Cardelli et al. (1989) for the correction in the other bands: $A_U = 0.153$, $A_V = 0.100$, $A_R = 0.084$, $A_I = 0.061$. The zero-magnitude flux densities have been taken from Bessell (1979).

The first evident feature is the presence of a U excess in the spectral slopes, probably due to the already mentioned inhomogeneity between CCD and photometer data. Indeed, when constructing the optical spectra from the data by Beskin et al. (1985) and Takalo et al. (1994), this excess does not appear. Another apparent feature is the simultaneous and systematic R

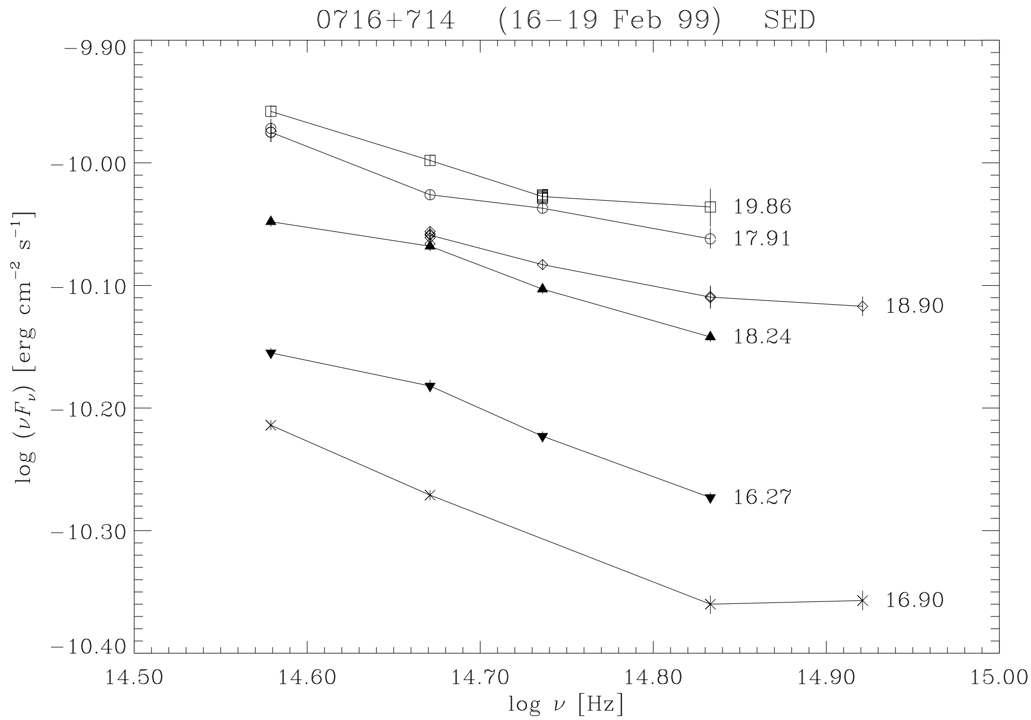

Fig. 6. Spectral energy distributions from the February 1999 data (February dates are indicated near the corresponding spectra); filled triangles represent Lowell data, while the other I data are from Vallinfreda, BVR ones from Torino, and U data from Catania

excess and I defect in the Lowell spectral slopes (filled triangles), which accounts for the small $R-I$ colour index noticed in Sect. 4.1.

It is also evident how the spectra are flatter with increasing brightness, as already pointed out by Ghisellini et al. (1997) when dealing with short-term variations, whereas the spectral slope seemed to be independent of the mean brightness state along longer-term smoother variations. As a matter of fact, we can now see that, four years later and with a similar brightness range, the 0716+714 optical spectra present a quite different mean slope.

Our spectral indexes range from $\alpha_{BI}=1.31$ to 1.57 ($F_\nu \propto \nu^{-\alpha}$). Part of the difference is surely due to the different Galactic extinction adopted ($A_V=0.23$ in Ghisellini et al. 1997), but, when computing our index range with that extinction, we still find higher values: $\alpha_{BI}=1.16$–1.43, to be compared with the range $\alpha=0.81$–1.15 obtained in February–April 1995, with a mean value $\alpha=0.94$. From observations carried out in February–March 1994 (during a faint, quiescent state), Sagar et al. (1999) found spectra a bit flatter than the 1995 ones: $\alpha_{BI}=0.81$–1.01 with a mean value of 0.84.

Thus, optical spectra seem to have steepened during the last five years, as if the synchrotron peak (in the νF_ν representation) had shifted along the optical band towards lower frequencies in this period, just as predicted by the helical-jet interpretation (Villata & Raiteri 1999) modelled on the X-ray observations by ROSAT and BeppoSAX (Ostorero et al. 2000; Villata et al. 2000b). According to that model, the synchrotron-peak shift is expected as the consequence of the rotation of the helical jet around its axis. This rotation changes the viewing angle (and the beaming factor) of each part of a curved and inhomogeneous jet: the infrared-emitting portion is now more aligned to our line of sight than some years ago, while the optical one has acquired a larger viewing angle.

5. Conclusions

We have presented the results from the WEBT campaign of February 1999 on the blazar 0716+714. Our dataset represents the first attempt to monitor a blazar so intensively during a few-day period. Despite the gaps due to lack of observations from the eastern hemisphere, we obtained a very dense coverage, never achieved before for any blazar: during the 72 hours of the originally scheduled observing period, 635 optical observations were carried out, with a mean rate of about 9 observations per hour. During the extended period February 15–22, the best-sampled bands have been B and I, with 266 and 306 data, respectively. Such a huge and dense dataset has allowed us to fix some features in the IDV properties of this object.

From the light curves we have extracted information on the fastest variability episodes, and have found that a slope of $\sim 0.002\,\mathrm{mag}$ per minute characterizes all of them, both on rising and on declining phases, thus constraining physical and geometrical properties of the emission region.

We were also interested in evaluating the possibility of a time delay between variations in different optical bands: we have fixed an upper limit of 10 minutes between B and I variations, thanks to a high-precision and well-sampled dataset obtained with a $1.8\,\mathrm{m}$ telescope.

Finally, we have discovered that the optical spectrum, besides its already known short-term slope variability (flatter-when-brighter during fast variations), has steepened in comparison with previous campaigns (1994–1995), showing a synchrotron-peak shift from the optical band towards lower energies.

This kind of whole-Earth monitoring of blazars has thus proved to be very useful and potentially rich of results, even in the form of a "trial" campaign as in the present case, involving only optical telescopes and without a whole longitude coverage. For the future, our purpose is to obtain really continuous and as dense as possible light curves, concentrating our activity during multiwavelength campaigns, in order to shed light on the ambiguous behaviours observed in the correlations among different-energy emissions in all the detectable electromagnetic spectrum.

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