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Long term variability of S5 0716+714 from the Asiago archive plates

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Abstract. We present the historic light curve of the BL Lac object S5 0716+714, spanning the time interval from 1953 to 2003, built using Asiago archive plates and our recent CCD observations. The source shows an evident long term variability, over which short term variations are superposed. We can model the source behaviour with an average monotonic brightness increase, since about 1975. This behaviour might be due to a precessing motion of the jet, as already suggested in the literature for other BL Lac objects. We remark the importance of preserving and digitizing the astronomical plate archives which are fundamental facilities to perform long term variability studies.

Key words. BL Lacs: photometry – BL Lacs: individual S5 0716

1. Introduction

Long term (≥ 10 years) optical light curves are available only for a small number of BL Lac objects. These curves generally show long-term trends occurring over time scales of several decades, over which the large short-term variability is superposed. The nature of these secular variations is unclear: a suggestive possibility is that they can be associated with changes in the structure and/or direction of the inner jet.

In this paper we focus our attention on the long-term behaviour of S5 0716+714 for which a detailed study of proper motions in the jet, based on a dense VLBI images database, has been performed by Bach et al. (2005).

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2. Observations

We found 53 useful plates containing our source in the Asiago Observatory archive: 46 of them were obtained with the 50/40/120 cm Schmidt telescope and 8 with the 90/67/245 cm one. These plates were taken as part of the Supernova sky patrol of the Asiago Observatory and were never used before for the study of S5 0716+714. The covered time interval is from February 1961 to January 1985, but with a highly uneven sampling. The dataset includes several filter/emulsion combinations, characterized by different effective wavelengths: 103aO+GG13 (closely matching the Johnson's B filter), 103aO (3600-5000 Å), TriX (3600-6700 Å) and Panchro Royal (3800-6400 Å). Plates were digitized at the Asiago Observatory with an EPSON 1680 Plus scanner as part of the Italian National

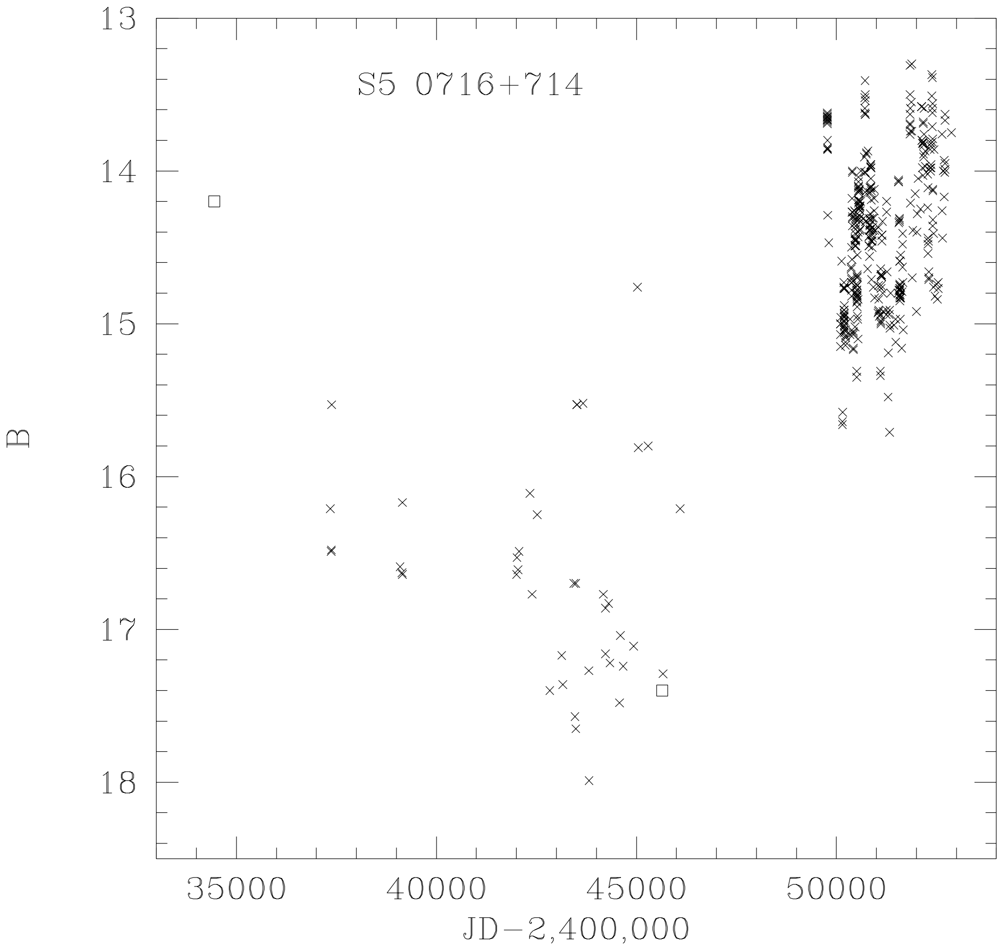

Fig. 1. The historic light curve in the *B* band of S5 0716+714 from February 1953 to August 2003. Data after JD 47000 are from our CCD monitoring, earlier data are from the Asiago archive. Two additional point from POSS-1 and Quick-V plates are also plotted as open squares.

Program of Digitization of Astronomical Plate Archives (Barbieri et al. 2003). A sampling step of 16 micron (1600 dpi) was used, in grayscale/transparency mode and 16 bit resolution. Plate scanning included also the unexposed borders to measure the plate fog level F. The scanning of a whole plate takes about 5 minutes. Due to the presence of a residual scattered light in the scanner, we found that the instrumental zero value Z for each plate was better evaluated using the central pixels of the most overexposed star. The transformation of the recorded plate transparency T of each pixel into a relative intensity I was obtained applying the simple relation

$I = (F - Z)/(T - Z)$

which is equivalent to the assumption that the contrast (γ) of the plate is 1.0. We found our source significantly fainter in the Asiago plates than in the recent CCD images and consequently we extended the photometric sequence of Villata et al. (1998), limited to B=14.7, to fainter stars. To this purpose we selected ∼20 stars around our source (including Villata's ones) ranging from B=11.5 to 17.7 and used 12 CCD frames of the field, obtained with the Vallinfreda telescope, to perform a calibration of this new sequence. Instrumental magnitudes for each plate were obtained using IRAF APPHOT tasks with a fixed aperture of 2.5 pixels for the 40cm Schimdt plates and 4.0 pixels for the 67cm plates, corresponding to the FWHM of the average stellar profiles. Four of the selected stars were found to be variable, two of them having quite red colours ($B - R \simeq 2$), and were therefore excluded from the reference set. Finally, for each plate a calibration curve (2nd order polynomial) was obtained using the CCD B values of our reference stars. No remarkable difference were found in these curves for the various plate/emulsion combinations. The B magnitude of S5 0716+714 in each plate was then derived from the instrumental one using the fitted calibration curve: typical rms errors are 0.1 mag for the 67cm Schmidt, while for the 40cm Schmidt they range from 0.15 at B=14 to 0.30 at B=17.5. Two additional points were obtained from the POSS 1 (year 1953) blue plate and from the Quick V (year 1983) digitized plates. Their magnitudes were estimated using the same reference stars and data reduction procedure used for the Asiago plates, save that V magnitudes were used to calibrate the photometric sequence on the Quick V plate and the V magnitude of S5 0716+714 was converted to B assuming $B - V$=0.45 (Raiteri et al. 2003).

3. Conclusions

The historic light curve of S5 0716+714 in the B band spanning the time interval 1953-2003 is shown in Fig. 1. The most remarkable feature is that the source was significantly fainter in the years 1961-1985 than in the years 1994-2003, but short term variability was present also in those years with an amplitude comparable to that observed after 1994. The average source brightness since the late seventies may be described by a monotonic increasing trend with a slope of ∼0.11 mag/year up to now. The long term variability trend could be interpreted as due to a slow precession of the jet, as already suggested by several authors (e.g., Gopal-Krishna & Wiita 1992; Rieger 2004; Caproni & Abraham 2004a,b) for some BL Lac objects (3C 345, 3C 120). A quantitative analysis for the case of S5 0716+714, combined with VLBI data published by Bach et al. (2005) is discussed by us in a forthcoming paper (Nesci et al. 2005). A relevant result of this analysis is that the jet should now be nearly aligned with our line of sight and therefore in the next years the increasing trend should stop and become a decreasing one with a similar slope. The next decade of observations will tell us if this scenario is correct.

We remark that this research would not be easily feasible without the funding of the Program of Digitization of the Italian Astronomical Plate Archives. Such archives are fundamental facilities to perform long term variability studies for any kind of astronomical sources and should be therefore preserved with great care for the use by the next generations of astronomers.

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