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VLBI observations of blazar 0716+714 during the outburst in spring 2004: 3-mm VLBA observations during the multifrequency session and possibility of IDV search in VLBI data.

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We present an analysis of the 3-mm VLBA observations of the blazar S5 0716+714 obtained in November 2003 during the broad-band observational campaign which took place before the powerful optical flare in March 2004. These data are a part of a multifrequency VLBA monitoring of the object and cover the period before, during and after the outburst. In November 2003, the source was reported to display the inter-day variability at 3 mm as observed by 30-m IRAM telescope. We attempted to detect the IDV in both total flux and polarization using the 3-mm VLBA data obtained close to the IRAM observing session. We present a method for the total flux variation search within the interferometric data, test this method on the 8-hour 3-mm VLBA observation and discuss the results and problems of the usage of the method. Also, we try to figure out what features should the VLBI experiment have to be suitable for the search for rapid variation of amplitude and what limitations are caused by the technical reasons.

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1. Introduction

Blazar S5 0716+714 is the very active source in the class. VLBI maps show core-dominated structure with the parsec-scale jet pointing at the position angle of 30°. The radio spectrum of 0716+714 is flat. The source is reported to display intra-day variability in optical, millimetre and sub-millimetre wavebands ([1], [2], [3], [4] and references therein, [5]). IDV was also observed with VLBI. Rapid variations of both total and polarized flux as well as polarization position angle were reported at centimetre wavelengths ([6], [7]).

2. Observations and data reduction

Our VLBA project consists of 5 epochs of polarization observations of 0716+714 at 5 frequencies carried out in 2004, and one 86-GHz observation at 6 Nov 2003. It covers the period before, during and after the powerful optical outburst in March 2004. Here, we analyze 86-GHz observation carried out on 6 Nov 2003 during the multifrequency campaign in Oct-Nov 2003 ([4]) and close in time to the mm-campaign with the IRAM 30-m telescope on Pico Veleta, Spain that observed the IDV event ([5]).

A priori amplitude calibration was done in AIPS using standard methods for high-frequency data and the standard phase calibration in the same run both for the program source and the calibrators. Maps were made with Difmap package using standard methods.

3. Polarization angle and total flux variability

First we tried to search for the polarization angle rotation. We split the initial *a priori* calibrated data into 2 sets of nearly equal duration and mapped them independently. There were substantially less data points in the second set because of the big amount of bad data points to be flagged. Possibly, it resulted from the low source elevation. For that reason we failed to map the polarization of the second data set. Therefore, so far we cannot say that the polarization properties of the source vary on the timescale of 8 hours.

The second task was to search for the total flux variations. The assumption was that if all the instrumentation effects were excluded, the residual variations of the source could be observed. If residual variations of the visibility amplitude are correlated at several independent baselines and the calibrators are stable, they represent the real variability of the source. We chose 4 antennae with smooth calibration gain curves and tested the method on one long (MK-KP) and one short (OV-PT) baselines (Fig. 1). To extract possible amplitude variations of 0716+714, we divided the visibility data by the source model to minimize the influence of the source structure. The same was done with the calibrators (OJ287 and 3C279). Finally, we fitted a straight line to the amplitudes of each source. They showed a decreasing trend. This could be explained as a result of opacity correction when the source was setting.

The extrinsic amplitude variations were due to: pointing errors (fast variations were most likely due to the wind gusts), problems in opacity correction and unknown gain-elevation dependence of the antennae.

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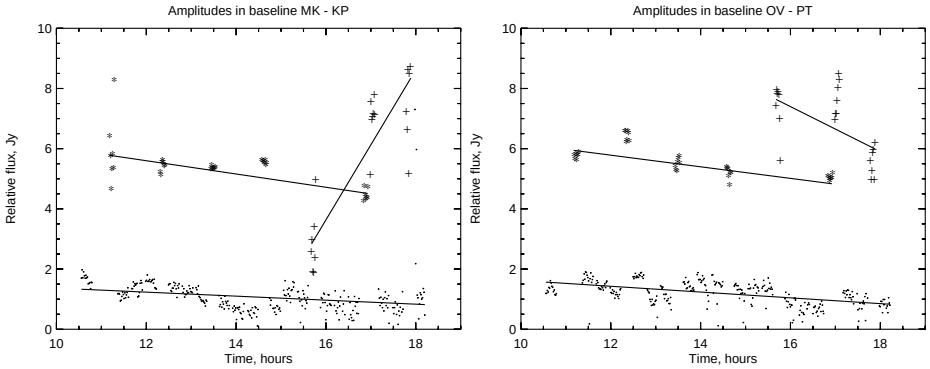

Figure 1: Visibility amplitudes for MK-KP and OV-PT baselines for 0716+714 and calibrators

Based on this data, it is only possible to say that the flux of this source was not varying significantly during this observation; the slightly rising trend is within the errors of the slopes. Non-variable calibrators could help to check the significance of the above mentioned factors. Unfortunately, in this experiment, the number of calibrators scans as well as the elevation range within they were observed were less than desired. The use of closure amplitudes could eliminate the strictly antenna-based errors like fast pointing and opacity errors. Unfortunately, bad opacity model tends to be baseline-based: the calibrators are usually selected to be as close as possible to the program source and so for most of the antennae they are rising and setting roughly at the same time. Like all baseline-based errors, opacity effects cannot be fully avoided with the use of closure amplitudes.

4. Results

We attempted to search for the IDV in VLBA 3-mm 8-hour session data observed close to the reported single dish 3-mm IDV event. We failed to map the polarization. The total flux variation search did not bring any results either, but we suppose the method could be successful, provided that longer sets of VLBA data with more frequent calibrator observations and wider range of elevations of the sources observed being used.

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