Polarization calibration of the VLBA using the D-terms
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ABSTRACT

We have studied the variation of the Very Long Baseline Array (VLBA) D-terms, which characterize the instrumental polarization, through monthly 22 and 43 GHz polarimetric observations over 16 epochs of the compact extragalactic sources 3C 120, 3C 279, 0420−014, OJ 287, 3C 454.3, and BL Lac. Most of the antennas are found to have D-terms that remain stable over the 16-month duration of the program. This stability is sufficient to allow calibration of the absolute orientation of the electric vector position angle by comparison of the D-terms against a set of tabulated values. This calibration can be achieved with errors of approximately 5° and 6° at 22 and 43 GHz, respectively; of the order as those obtained by calibration using observations of sources with both the VLBA and the Very Large Array.

1. Introduction

The lack of submilliarcsecond-scale, stable electric vector position angle (EVPA) polarization calibrators renders the calibration of the absolute right-left (R-L) circular polarization phase offset in polarimetric very long baseline interferometric (VLBI) observations a difficult task at high radio frequencies. Therefore, standard calibration of the true EVPA orientation in images derived from VLBI data, e.g., those obtained with the Very Long Baseline Array (VLBA), is achieved by comparison with quasi-simultaneous Very Large Array (VLA) or single-dish observations. This calibration is based on the assumption that observations with the VLBA (integrated over the image) and the VLA are probing the same configuration of the magnetic field. Because of the vastly different angular resolution of the VLBA and

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VLA, calibration sources with negligible, or at least quantifiable, large scale polarization are required.

An alternative method for calibrating the EVPA on VLBA images is to use the VLBA pulse calibration system. As discussed by Leppänen, Zensus, & Diamond (1995), this might provide a very accurate EVPA calibration for VLBA observations at 22 GHz, but cannot be used at 43 GHz.

The jets of some strong calibrators, e.g., 3C 279, contain knots of emission whose EVPAs seem reasonably stable; however most of these features have been found to be too short-lived or to have variations in their EVPAs, rendering them unreliable for calibration. Starting in 1999 September, S. T. Myers and G. Taylor have been carrying out a VLA monitoring program of a number of possible calibration sources at different frequencies (Taylor & Myers 2000). The results of this program are available on the National Radio Astronomy Observatory's (NRAO) web page [http://www.aoc.nrao.edu/∼smyers/calibration]. Several sources (∼7) have been observed to present a stable EVPA over the two week interval at which they are monitored. By including one or more calibration sources in each VLBA polarimetric observing program observers can interpolate the results of the monitoring in time and frequency to determine the EVPA correction with accuracies of the order of 5-3 degrees (Zavala & Taylor 2001). This has the disadvantage of taking considerable VLBA observing time away from the target objects.

Leppänen, Zensus, & Diamond (1995) suggested an alternative calibration of the VLBA EVPAs based on the assumption that the feed D-terms (instrumental polarization parameters) change slowly with time. In this paper we report on the stability of the VLBA D-terms over more than one year of monthly polarimetric observations at 22 and 43 GHz. This stability allows calibration of the VLBA EVPAs as accurate as that obtained by comparison with VLA or single-dish observations.

2. VLBA observations and data analysis

We carried out VLBA observations as part of a monthly polarimetric 22 and 43 GHz monitoring program aimed to study the inner structure of the radio galaxy 3C 120 (Gómez et al. 2000, 2001). These observations, covering a total of sixteen epochs, were obtained on the following dates: 1997 November 10, 1997 December 11, 1998 January 11, 1998 February 7, 1998 March 9, 1998 April 10, 1998 May 9, 1998 June 11, 1998 July 11, 1998 August 13, 1998 September 16, 1998 October 26, 1998 December 3, 1999 January 10, 1999 February 10, and 1999 March 19.

The data were recorded in 1-bit sampling VLBA format with 32 MHz bandwidth per circular polarization. We reduced the data with the AIPS software in the usual manner (e.g., Leppänen, Zensus, & Diamond 1995). We refer the reader to Gómez et al. (2000, 2001) for further details regarding the data reduction. We determined the instrumental polarization by using the linear feed solution algorithm developed by Leppänen, Zensus, & Diamond (1995). This provided a set of D-terms for each epoch and frequency.

3. Calibration of the absolute VLBA polarization position angle

3.1. Comparison with VLA observations

For this we carried out a total of fourteen (typically two-hour) VLA observations at the following epochs: 1997 November 21, 1997 December 14, 1998 January 15, 1998 February 12, 1998 March 7, 1998 April 8, 1998 June 9, 1998 July 11, 1998 August 14, 1998 September 19, 1998 October 29, 1998 November 28, 1999 February 17, and 1999 March 17. We used as calibrators the blazars 0420−014 and OJ 287, as well as the target source 3C 120, to compare the VLA and VLBA integrated polarization position angles. Besides the VLBA calibrators, we observed the standard VLA gain and polarization calibrators 3C 286, 3C 138, 3C 147, and 3C 48, with the choice depending on the scheduled time range. The integrated VLA EVPAs of 3C 120 and the calibrators thus measured are given in Table 1.

We have estimated the EVPA corrections $\Delta\chi_s$ required to bring the VLBA EPVAs into agreement with those measured with the VLA for the calibration sources 0420−014 and OJ 287 as well as for the source 3C 120. These are listed in Tables 2 and 3 for 22 and 43 GHz, respectively. The calibration using the VLA was adopted only at those epochs (about half of the total, listed in bold type in Tables 2 and 3) at which the derived value of $\Delta\chi_s$ for 0420−014 and OJ 287 differ by $\leq 10°$. For the remaining epochs the final rotation $\Delta\chi$ is a combination of the calibration obtained using the D-terms ($\Delta\chi_D$; see section 3.2), $\Delta\chi_s$ of one the calibrators, and comparison of the apparently stable EVPAs of certain features on the images with those at other epochs (see 3.1.1). This criterion was also used at some epochs to introduce small corrections to $\Delta\chi$ obtained using the VLA.

Although both of the calibrators provide a similar $\Delta\chi_s$ only for about half of the epochs, we note that, at most of the epochs, the EVPA of at least one of the calibrators agrees with the final $\Delta\chi$ adopted. For 0420−014 only epochs 1998 April and 1998 September (1998 March and 1998 August) at 22 GHz (43 GHz) are in clear disagreement. This is most likely due to rapid changes in the innermost VLBA polarization structure that occurred during the short time span between the VLBA and VLA observations. It is interesting to note that this disagreement is always observed first at the higher frequency, as expected for newly born features in the jet that are initially opaque at lower frequencies. We observe the same behavior in OJ 287, for which the ejection of a new feature produces a clear disagreement between $\Delta\chi_s$ and $\Delta\chi$ for epochs 1998 January, 1998 February and 1998 March (1997 December, 1998 January, 1998 February, and 1998 December) at 22 GHz (43 GHz).

It is also interesting to compare the values of $\Delta\chi$ with $\Delta\chi_s$ for the source 3C 120. At both observing frequencies there is a systematic difference of about 15° for all epochs, with larger deviations observed at 43 GHz. This is consistent with extended polarized flux density present on VLA scales, but resolved on VLBA scales, with an EVPA of 15°. This is in agreement with the polarization at larger scales observed by Walker, Benson, & Unwin (1987). Comparison between the integrated total flux density observed with the VLA and VLBA also shows a systematic missing (resolved out) VLBA flux density of 0.9 Jy at 22 GHz and 1.1 Jy at 43 GHz.

3.1.1. EVPA stability of jet components

Another possible source of EVPA calibration for VLBI observations is the presence of long-lasting, EVPA-stable features in the images of jets. For some time it was thought that one of the strongest sources, 3C 279, contained such a stable component at about 3 mas from the core, with a relatively high degree of polarization ($\sim$ 10%) and low rotation measure (Taylor 1998). However, our monitoring of 3C 279 reveals a progressive rotation of the EVPA in this component in 1998 at both 22 and 43 GHz. As shown in Tables 2 and 3, the EVPA of this feature changed from 64° in late 1997 at both 22 and 43 GHz, consistent with that reported by Taylor (1998) in early 1997, to a value close to 90° by 1998.1 at 43 GHz and 1998.9 at 22 GHz.

The radio galaxy 3C 120 contains a fast superluminal component, labeled D (d at 43 GHz) in Gómez et al. (2000, 2001), with a relatively constant EVPA (see Tables 2 and 3). However, this component dissipated during our monitoring. Although the jet of BL Lac contains a long-lasting, rather diffuse feature south of the core (component 10 of Denn, Mutel, & Marscher 2000), Tables 2 and 3 show that the EVPA of this component in BL Lac fluctuates too greatly at 22 and 43 GHz for this object to be considered a reliable EVPA calibrator.

The source OJ 287 contains a relatively strong feature located $\sim$1 mas from the core that has remained quasi-stationary in position during our monitoring (see also Jorstad et al. 2001). The EVPA for this component (see Tables 2 and 3) is observed to remain quasi-stationary as well throughout the duration of our monitoring. At 22 GHz (43 GHz) the mean EVPA is 85° (81°) with a standard deviation of only 8° (13°). This feature can therefore be used as an alternative EVPA calibrator at both 22 and 43 GHz.

The quasar 3C 454.3 contains a feature at ~ 0.6 mas west of the core that has been observed to remain stationary in position since its first detection in 1983.8 by Pauliny-Toth et al. (1987). Further VLBI observations (Cawthorne & Gabuzda 1996; Kemball, Diamond, & Pauliny-Toth 1996; Gómez, Marscher, & Alberdi 1999; Jorstad et al. 2001) detected linearly polarized flux in this component. Its degree of polarization varies between 1 and 9%, with a frequency dependent EVPA that may be accounted for by the integrated rotation measure of -57 radians m^{-2} obtained by Broten, Macleod, & Vallée (1988). As shown in Tables 2 and 3, we observe the EVPA of this component to remain quasi-stationary with mean values of $94 \pm 8°$ and $88 \pm 8°$ at 22 and 43 GHz, respectively. It therefore can be used as an alternative, reasonably reliable EVPA calibrator at 22 and 43 GHz. However, superluminal knots have been observed to pass through the position of this stationary feature (Jorstad et al. 2001). During such events, rapid variability of the EVPA can occur. For example, Gómez, Marscher, & Alberdi (1999) observed a difference in the EVPA of this component by $-40°$ with respect to that reported here at 22 GHz.

3.2. Calibration using the VLBA D-terms

As pointed out by Leppänen, Zensus, & Diamond (1995), the leakage factors (D-terms) offer an independent alternative method for calibrating the absolute R-L phase offset. Under the assumption that the D-terms vary slowly over time, this method is capable of providing an accurate *relative* calibration of the EVPAs across epochs that is intrinsic to the array. It does not require comparison with the VLA or single-antenna measurements beyond a one-time observation to set the absolute EVPA calibration at one epoch, although in practice it is wise to monitor the D-term stability through roughly monthly combined VLA and VLBA observations.

D-term phase solutions contain information on the R-L phase offset, so that rotation of the EVPAs by an angle χ translates into rotation of the RCP D-term phase by 2χ and the LCP phase by 360°-2χ. Therefore, the phase difference of the D-terms determines the *relative* R-L phase offset between two epochs. The method applies to both polarizations and all of the antennas in the array, which for the VLBA involves comparison of 20 different values. This reduces the error in the determination of the R-L offsets and allows calibration even if some of the antennas fail or contain data of poor quality. D-terms with larger amplitude specify the phase more precisely; therefore, antennas with relatively large instrumental polarization provide the most accurate calibration.

Tables 2 and 3 show the relative phase offset between the D-terms for each two consecutive epochs, $\Delta\chi_D$. It is possible to estimate the reliability of the calibration using the D-terms by comparing directly with the difference between $\Delta\chi$ for two consecutive epochs with a reliable EVPA calibration obtained using the VLA (those listed in bold type in Tables 2 and 3). For instance, for epochs 1997.86 and 1997.94 the mean values of $\Delta\chi_s$ obtained for 0420−014 and OJ 287 at 22 GHz (Table 2) are respectively -67° and 5°. (Note that these may differ from the final $\Delta\chi$ adopted values.) Therefore the relative $\Delta\chi$ offset between these two epochs is 72°, which differs from that obtained by comparison of the D-terms ($\Delta\chi_D$=78) by -6°. Values for this comparison ($\Delta\chi_{VLA} - \Delta\chi_D$) are given in Tables 2 and 3 for all the pairs of consecutive epochs for which there is a reliable calibration using the VLA. Mean differences between the VLA and D-term calibrations are 5° and 6° at 22 and 43 GHz, respectively. These are approximately within the errors in the calibration of the EVPAs obtained by using VLA observations; this demonstrates that the D-terms method yields similar accuracy while requiring less observational time.

Therefore, comparison of D-terms against a set of tabulated values (previously calibrated by other means) proves to be a reliable method for calibrating the absolute R-L phase offset in VLBA observations (independent of the reference antenna used), even at the highest frequencies. This method reduces significantly the effort of performing polarimetric VLBA observations: no supporting VLA or single-antenna observations are needed. It is therefore unnecessary to dedicate a significant amount of VLBA time to observe polarization position-angle calibrators to compare with the VLA: One needs only to observe the target source(s) plus a strong calibrator to detect fringes (if none of the target sources are bright enough for this purpose). The D-terms could then be obtained by an interpolation of tabulated values determined from roughly monthly combined VLBA and VLA observations at different frequencies. Note also that, at the same time, this provides the correct leakage factors necessary to remove the antennas' instrumental polarization.

3.2.1. D-term stability

Our observations across many epochs confirm that the D-terms vary sufficiently slowly to be defined by approximately monthly observations. Tables 4 and 5 show the amplitude and phase of the D-terms for all 16 monthly observations at 22 and 43 GHz, respectively. In order to allow a better study of the D-term stability, we have rotated the D-term phases in Tables 4 and 5 by $2\Delta\chi$, as listed in Tables 2 and 3. Mean values of the D-terms, thus rotated, over all our observing epochs are tabulated in Tables 6 and 7 for data at 22 and 43

GHz, respectively. Errors correspond to the standard deviation.

Changes in an antenna's receivers typically result in new values of that antenna's D-terms. As it is apparent in Tables 4 and 5, this occurred at the OVRO station at 22 GHz after 1998 July 1; the Brewster station at 22 GHz after 1997 December 7, although this change in receiver is observed to affect only the antenna's LCP D-terms; and the Los Alamos station at 43 GHz after 1998 April 30 and again after 1999 March 9. (Note: Until late 2001, the receiver change at Los Alamos on 1998 April 30 was erroneously listed as occurring at 22 GHz in the vlba_gains.key file that gives the parameters of each antenna; R. C. Walker, private communication.) The change in the 22 GHz receiver at the OVRO station on 1998 July 1 is also intriguingly observed to coincide with a modification of the antenna's D-terms at 43 GHz. We account for such sudden changes in the D-terms by computing mean values in Tables 6 and 7 for different time ranges. New 43 GHz receivers were installed at the St. Croix station in 1997 December 3 and 1998 September 24. While the LCP D-terms of this antenna were reasonably stable between 1997 December 3 and 1998 September 24, the RCP D-terms varied considerably throughout all of our observing epochs. After 1998 September 24, the D-terms of both polarizations at St. Croix experienced large fluctuations at 43 GHz.

The D-term phases of some VLBA antennas progressively rotated, usually accompanied by smooth variations in the amplitudes. This is particularly apparent for the Fort Davis, Kitt Peak, and Pie Town stations at 22 GHz and the Mauna Kea station at 43 GHz. For some of these antennas we have adopted separate mean values of the D-terms for different time ranges; this decreases the uncertainties of the mean values.

We can estimate the error in the calibration of the absolute EVPA obtained by comparison against the tabulated values of Tables 6 and 7. This error can be reduced by excluding stations with relatively large errors in the phases of the D-terms. By considering only those antennas with mean D-term phases smaller than 30°, we estimate an error in $\Delta\chi_D$ of 18° and 16° at 22 and 43 GHz, respectively. Provided that the error in the determination of $\Delta\chi$ is half these values, we conclude that calibration of the absolute EVPA by comparison of D-terms against those in Tables 6 and 7 leads to uncertainties of 9° and 8° at 22 and 43 GHz, respectively. These are quite similar to the errors expected when comparing VLBA with VLA or single-dish observations.

It is interesting to note that, over long time periods, the progressive change in the D-terms observed for some antennas – for which the Kitt Peak station at 22 GHz is the best example – results in rather large deviations of the actual D-terms at different epochs from the mean values. Therefore, calibration of the absolute EVPAs by comparison of nearby epochs (as we used when estimating $\Delta\chi_D$ in Tables 2 and 3) results in significantly smaller errors than by using the mean values over longer time ranges listed in Tables 6 and 7. Some of these D-terms (e.g., Kitt Peak at 22 GHz) show seasonal variations, which may be related to a dependence of the instrumental polarization on temperature. On the other hand, at some other stations, small fluctuations in the D-terms occur that appear to be random. In this case, the use of mean D-term values calculated over long time ranges provides a more accurate EVPA calibration. We further note that the uncertainty in the determination of $\Delta\chi_D$ is calculated from the errors in the D-term phases, which are smaller for larger D-term amplitudes. This explains why the D-term calibration of the EVPAs results in lower errors at 43 GHz than at 22 GHz: The D-term amplitudes at 43 GHz are systematically larger than at 22 GHz.

4. Conclusions

We find that the accuracy in the calibration of the R-L phase offset – which corresponds to a determination of the EVPA correction – is similar for both the D-term method and comparison of VLBA and VLA polarimetry. Furthermore, we have established that, for most of the antennas, the D-terms varied sufficiently slowly throughout the duration of our 16 months of monitoring to allow accurate interpolations between epochs of D-term calibration. This alternative method of calibrating the absolute EVPA orientation can simplify considerably polarimetric observations with the VLBA. Accurate measurements of the VLBA D-terms at different frequencies could be obtained at regularly spaced intervals through dedicated observations, which in turn could be calibrated by comparison with VLA observations to determine the correct R-L phase offset, or equivalently, the absolute D-term phases. Any other VLBA observations taken at the standard frequency could utilize these tabulated D-terms, thus allowing, at the same time, calibration of the absolute EVPAs (independent of the reference antenna used) and correction for the instrumental polarization. We feel that this would optimize the use of the VLBA (as well as eliminate the need for supporting VLA observations for individual projects), since no further observations of EVPA calibrators would be necessary. We estimate that a frequency of approximately once per month (as well as immediately following changes in the receivers of any of the VLBA antennas) for these dedicated D-term calibration observations would provide accurate calibration of the absolute EVPAs with errors of the order of several degrees at 22 and 43 GHz.

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Table 1. Integrated VLA EVPAs[a]

	3C 120		0420-014		OJ 287		Errors[b]	
Epoch	K	Q	K	Q	K	Q	K	Q
1997.89	-11	-14	-39	-29	71	72	4	4
1997.95	-7	-12	-48	-21	70	66	4	4
1998.04	-7	-20	-63	[-53]	-61	-44	2	4
1998.12	-9	-13	-79	-76	-32	[2]	4	10
1998.18	-8	23	17	48	-40	-55	6	8
1998.27	8	4	56	57	11	0	10	6
1998.44	-7	-7	86	80	-9	9	4	5
1998.53	-9	-21	68	70	-19	-11	5	8
1998.62	10	-25	85	54	-20	-18	5	10
1998.72	-11	-27	-53	-43	-38	-37	4	4
1998.83	-35	-20	-81	-85	-36	-10	4	8
1998.91	-54	-9	-81	-71	-62	-40	4	4
1999.13	-30	-16	-27	-52	77	78	4	4
1999.21	-23	-22	9	69	68	88	4	4

[a]Tabulated values (in degrees) for K-band (22 GHz) and Q-band (43 GHz)

[b]Mean estimated errors (in degrees) over all sources; values in brackets should be regarded as unreliable since they have large uncertainties

Table 2. VLBA EVPAs[a] at 22 GHz

	Rotations			3C 120			3C 279		0420−014		OJ 287			3C 454.3		BL Lac	
Epoch	$\Delta\chi$[b]	$\Delta\chi_D$[c]	$\Delta\chi_{VLA}-\Delta\chi_D$[d]	Int.[e]	Cp.[f]	$\Delta\chi_s$[g]	Int.	Cp.	Int.	$\Delta\chi_s$	Int.	Cp.	$\Delta\chi_s$	Int.	Cp.	Int.	Cp.
1997.86	**-66±9**	···	···	-21	32	-56±5	6	64	139	-64±5	74	···	-69±5	175	97	71	45
1997.94	**8±8**	78±8	-6	-13	26	14±5	9	68	138	2±5	70	86	8±5	131	100	40	35
1998.03	28±10	25±11	···	-17	28	38±5	31	70	117	28±5	108	91	39±5	94	98	30	37
1998.10	27±10	-1±13	···	-21	22	39±5	26	72	···	···	110	93	65±5	96	96	34	37
1998.19	28±10	1±6	···	-30	26	50±5	36	79	[5][h]	[40±15]	149	[81]	19±5	81	74	-3	-15
1998.27	11±10	-17±3	···	-11	19	30±10	···	···	27	40± 10	···	···	···	100	96	7	-5
1998.35	11±10	0±4	···	-33	17	···	42	81	163	···	154	98	···	99	101	21	2
1998.44	**-20±5**	-28±5	···	-25	13	-2±5	41	79	86	-20±5	172	100	-21±5	90	84	11	5
1998.53	**-105±5**	-85±4	0	-22	19	-92±5	48	81	65	-102±5	163	88	-107±5	99	96	15	12
1998.62	11±10	116±6	···	0	20	21±5	37	79	[47]	[49±15]	161	76	10±5	93	98	19	16
1998.71	-106±10	63±12	···	-48	24	-69±5	29	···	107	-86±5	140	···	-104±10	···	···	-1	-8
1998.82	**-102±5**	4±6	···	-67	···	-70±5	32	83	94	-97±5	148	76	-106±5	81	87	28	20
1998.92	**7±7**	103±7	+9	-67	32	20±5	42	88	101	5±5	111	79	14±5	82	89	19	18
1999.03	-103±10	67±20	···	-52	···	···	45	87	65	···	99	81	···	93	96	25	9
1999.12	**-73±8**	30±6	···	-40	···	-63±5	50	96	146	-66± 10	77	83	-73±5	105	103	28	16
1999.21	**30±7**	104±8	-4	-44	···	51±5	40	86	11	28±10	67	75	31±5	93	95	···	···

[a] All values given in degrees. Errors as given in $\Delta\chi$

[b] EVPA rotation required to calibrate the absolute EVPAs. The most reliable values, shown in bold typeface, are those for which two or more of the calibrators provide a common calibration

[c] EVPA rotation across two consecutive epochs obtained from comparison of the D-terms

[d] Difference between the mean value of $\Delta\chi_s$ obtained for 0420−014 and OJ 287 and $\Delta\chi_D$. See text

[e] Source-integrated EVPA

[f] EVPA for a particular jet component (see text)

[g] Suggested EVPA rotation needed for the VLBA and VLA EVPAs to agree

[h] Values in brackets should be regarded as unreliable since they have large uncertainties

Table 3. VLBA EVPAs[a] at 43 GHz

	Rotations			3C 120			3C 279		0420−014		OJ 287			3C 454.3		BL Lac	
Epoch	$\Delta\chi$[b]	$\Delta\chi_D$[c]	$\Delta\chi_{VLA} - \Delta\chi_D$[d]	Int.[e]	Cp.[f]	$\Delta\chi_s$[g]	Int.	Cp.	Int.	$\Delta\chi_s$	Int.	Cp.	$\Delta\chi_s$	Int.	Cp.	Int.	Cp.
1997.86	**36±7**	···	···	-19	28	41±10	-14	···	-35	42±7	76	···	32±7	83	82	30	44
1997.94	44±10	8±9	···	-4	19	36±10	-4	[63][h]	-14	37±10	[49]	[88]	[61±50]	89	87	27	42
1998.03	41±10	-3±8	···	-30	19	51±10	17	[71]	-35	23±20	106	88	71±10	78	81	23	37
1998.10	43±15	2±7	···	-33	28	63±10	21	[87]	···	···	111	96	-66±10	82	84	30	3
1998.19	44±15	-4±10	···	45	19	22±10	33	[88]	22	70±15	-43	···	32±10	71	70	···	···
1998.27	50±10	4±11	···	5	29	49±10	57	[86]	48	59±10	3	···	46±10	93	96	0	-9
1998.35	103±10	49±13	···	-17	···	···	57	···	55	···	-24	[103]	···	89	97	36	[3]
1998.44	**-52±8**	23±10	···	-20	20	-39±10	59	84	81	-53±8	7	···	-50±8	90	86	21	15
1998.53	**-94±10**	145±9	-7	-52	21	-63±10	57	88	66	-90±15	-7	···	-98±10	93	91	28	18
1998.62	-82±10	16±6	···	-49	20	-58±10	40	···	25	-53±15	-21	67	-79±10	82	85	47	[4]
1998.71	**82±8**	-13±8	···	-53	···	108±10	41	[79]	-35	74±8	-37	76	82±8	90	92	26	[19]
1998.82	**-81±8**	17±11	4	-49	···	-52±10	49	···	-85	-81±8	-9	70	-82±8	87	92	28	[14]
1998.92	94±10	-5±11	···	-59	···	-36±10	50	[84]	-71	94±10	103	61	131±10	78	82	8	8
1999.03	80±15	157±6	···	-32	···	···	56	83	-60	···	114	[71]	···	95	83	29	18
1999.12	35±10	-45±15	···	-19	···	38±10	62	81	-41	24±10	84	[84]	[29±10]	93	95	[48]	···
1999.21	88±8	46±16	···	-20	···	86±10	56	89	···	···	88	85	88±8	99	99	···	···

[a] All values given in degrees. Errors as given in $\Delta\chi$

[b] EVPA rotation required to calibrate the absolute EVPAs. The most reliable values, shown in bold typeface, are those for which two or more of the calibrators provide a common calibration

[c] EVPA rotation across two consecutive epochs obtained from comparison of the D-terms

[d] Difference between the mean value of $\Delta\chi_s$ obtained for 0420−014 and OJ 287 and $\Delta\chi_D$. See text

[e] Source-integrated EVPA

[f] EVPA for a particular jet component (see text)

[g] Suggested EVPA rotation needed for the VLBA and VLA EVPAs to agree

[h] Values in brackets should be regarded as unreliable since they have large uncertainties

Table 4. 22 GHz VLBA D-Terms[a]

Epoch	BR	FD	HN	KP	LA	MK	NL	OV	PT	SC
					Right Circular Polarization					
1997.86	$0.0341e^{i145}$	$0.0005e^{i285}$	$0.0210e^{i79}$	$0.0135e^{i96}$	$0.0150e^{i348}$	$0.0212e^{i356}$	$0.0154e^{i43}$	$0.0582e^{i93}$	$0.0115e^{i242}$	$0.0649e^{i260}$
1997.94	$0.0244e^{i132}$	$0.0014e^{i275}$	$0.0190e^{i53}$	$0.0103e^{i96}$	$0.0197e^{i330}$	$0.0186e^{i337}$	$0.0189e^{i66}$	$0.0692e^{i100}$	$0.0192e^{i239}$	$0.0674e^{i255}$
1998.03	$0.0228e^{i132}$	$0.0037e^{i249}$	[$0.0197e^{i359}$][b]	$0.0118e^{i93}$	$0.0223e^{i311}$	$0.0051e^{i350}$	$0.0173e^{i26}$	$0.0721e^{i95}$	$0.0125e^{i240}$	$0.0603e^{i241}$
1998.10	$0.0324e^{i124}$	$0.0067e^{i145}$	$0.0286e^{i67}$	$0.0193e^{i99}$	$0.0124e^{i337}$	$0.0083e^{i354}$	$0.0224e^{i49}$	$0.1134e^{i105}$	$0.0117e^{i199}$	$0.0673e^{i245}$
1998.19	$0.0367e^{i124}$	$0.0101e^{i135}$	$0.0466e^{i77}$	$0.0224e^{i101}$	$0.0118e^{i342}$	$0.0011e^{i282}$	$0.0154e^{i64}$	$0.0794e^{i97}$	$0.0101e^{i186}$	$0.0627e^{i248}$
1998.27	$0.0310e^{i128}$	$0.0104e^{i180}$	$0.0309e^{i68}$	$0.0245e^{i104}$	$0.0108e^{i299}$	$0.0029e^{i345}$	$0.0288e^{i52}$	$0.0726e^{i94}$	$0.0127e^{i182}$	$0.0627e^{i244}$
1998.35	$0.0324e^{i122}$	$0.0091e^{i187}$	$0.0412e^{i66}$	$0.0253e^{i103}$	$0.0109e^{i304}$	$0.0098e^{i291}$	$0.0270e^{i39}$	$0.0714e^{i93}$	$0.0111e^{i186}$	$0.0660e^{i246}$
1998.44	$0.0239e^{i102}$	$0.0068e^{i186}$	$0.0333e^{i60}$	$0.0206e^{i94}$	$0.0117e^{i298}$	$0.0134e^{i345}$	$0.0268e^{i39}$	$0.0726e^{i92}$	$0.0100e^{i195}$	$0.0617e^{i244}$
1998.53	$0.0224e^{i103}$	$0.0028e^{i201}$	$0.0339e^{i59}$	$0.0232e^{i89}$	$0.0129e^{i324}$	$0.0073e^{i23}$	$0.0302e^{i35}$	$0.0325e^{i49}$	$0.0059e^{i203}$	$0.0683e^{i250}$
1998.62	$0.0231e^{i120}$	$0.0029e^{i110}$	$0.0293e^{i64}$	$0.0177e^{i102}$	$0.0129e^{i297}$	$0.0083e^{i296}$	$0.0263e^{i30}$	$0.0198e^{i51}$	$0.0079e^{i213}$	$0.0708e^{i248}$
1998.71	$0.0244e^{i103}$	$0.0032e^{i36}$	[$0.0357e^{i3}$]	$0.0208e^{i70}$	$0.0175e^{i326}$	$0.0247e^{i347}$	$0.0337e^{i10}$	$0.0305e^{i41}$	$0.0075e^{i226}$	$0.0771e^{i246}$
1998.82	$0.0185e^{i86}$	$0.0025e^{i57}$	$0.0300e^{i55}$	$0.0168e^{i86}$	$0.0093e^{i317}$	$0.0187e^{i350}$	$0.0247e^{i31}$	$0.0277e^{i48}$	$0.0046e^{i205}$	$0.0618e^{i251}$
1998.92	$0.0238e^{i122}$	$0.0039e^{i79}$	$0.0382e^{i63}$	$0.0187e^{i102}$	$0.0194e^{i4}$	$0.0180e^{i360}$	$0.0240e^{i38}$	$0.0230e^{i51}$	$0.0095e^{i186}$	$0.0906e^{i240}$
1999.03	[$0.0146e^{i48}$]	$0.0041e^{i348}$	$0.0232e^{i71}$	$0.0184e^{i77}$	$0.0275e^{i353}$	$0.0199e^{i47}$	$0.0163e^{i53}$	$0.0216e^{i51}$	$0.0051e^{i255}$	$0.0504e^{i258}$
1999.12	$0.0201e^{i105}$	$0.0100e^{i348}$	$0.0230e^{i67}$	$0.0152e^{i88}$	$0.0252e^{i360}$	$0.0216e^{i21}$	$0.0204e^{i27}$	$0.0247e^{i65}$	$0.0103e^{i277}$	$0.0846e^{i267}$
1999.21	[$0.0221e^{i72}$]	$0.0038e^{i55}$	[$0.0297e^{i39}$]	$0.0202e^{i75}$	$0.0207e^{i356}$	$0.0269e^{i22}$	$0.0318e^{i35}$	$0.0321e^{i69}$	$0.0027e^{i233}$	$0.0748e^{i256}$
					Left Circular Polarization					
1997.86	$0.0214e^{i134}$	$0.0128e^{i311}$	$0.0049e^{i52}$	$0.0110e^{i150}$	$0.0155e^{i275}$	$0.0164e^{i267}$	$0.0163e^{i108}$	$0.1271e^{i300}$	$0.0190e^{i133}$	$0.0575e^{i261}$
1997.94	$0.0092e^{i69}$	$0.0212e^{i315}$	$0.0121e^{i80}$	$0.0119e^{i192}$	$0.0166e^{i287}$	$0.0191e^{i244}$	$0.0086e^{i100}$	$0.1500e^{i318}$	$0.0180e^{i141}$	$0.0806e^{i271}$
1998.03	$0.0047e^{i47}$	$0.0209e^{i311}$	[$0.0040e^{i356}$]	$0.0122e^{i170}$	$0.0224e^{i286}$	$0.0186e^{i307}$	$0.0046e^{i112}$	$0.1438e^{i323}$	$0.0138e^{i140}$	$0.0706e^{i269}$
1998.10	$0.0209e^{i43}$	$0.0144e^{i337}$	$0.0185e^{i91}$	$0.0119e^{i137}$	$0.0156e^{i328}$	$0.0112e^{i309}$	$0.0108e^{i100}$	$0.1364e^{i343}$	$0.0170e^{i121}$	$0.0666e^{i268}$
1998.19	$0.0230e^{i65}$	$0.0143e^{i352}$	$0.0332e^{i98}$	$0.0131e^{i122}$	$0.0172e^{i319}$	$0.0075e^{i325}$	[$0.0053e^{i25}$]	$0.1365e^{i325}$	$0.0191e^{i113}$	$0.0657e^{i263}$
1998.27	$0.0203e^{i50}$	$0.0100e^{i337}$	$0.0232e^{i99}$	$0.0128e^{i107}$	$0.0173e^{i308}$	$0.0066e^{i290}$	$0.0142e^{i97}$	$0.1343e^{i324}$	$0.0169e^{i111}$	$0.0666e^{i264}$
1998.35	$0.0222e^{i58}$	$0.0096e^{i323}$	$0.0301e^{i104}$	$0.0110e^{i101}$	$0.0162e^{i291}$	$0.0063e^{i208}$	$0.0113e^{i114}$	$0.1297e^{i321}$	$0.0125e^{i112}$	$0.0649e^{i263}$
1998.44	$0.0169e^{i49}$	$0.0104e^{i327}$	$0.0199e^{i108}$	$0.0106e^{i125}$	$0.0161e^{i299}$	$0.0086e^{i229}$	$0.0153e^{i114}$	$0.1323e^{i327}$	$0.0160e^{i134}$	$0.0667e^{i269}$
1998.53	$0.0129e^{i68}$	$0.0077e^{i286}$	$0.0192e^{i109}$	$0.0160e^{i139}$	$0.0157e^{i275}$	$0.0039e^{i279}$	$0.0100e^{i111}$	$0.1072e^{i326}$	$0.0146e^{i130}$	$0.0698e^{i262}$
1998.62	$0.0171e^{i70}$	$0.0134e^{i330}$	$0.0177e^{i107}$	$0.0117e^{i148}$	$0.0190e^{i280}$	$0.0071e^{i199}$	$0.0058e^{i95}$	$0.1091e^{i330}$	$0.0103e^{i145}$	$0.0689e^{i267}$
1998.71	$0.0141e^{i84}$	$0.0146e^{i294}$	$0.0065e^{i84}$	$0.0205e^{i158}$	$0.0145e^{i266}$	[$0.0057e^{i163}$]	[$0.0102e^{i193}$]	$0.1087e^{i331}$	$0.0231e^{i152}$	$0.0807e^{i275}$
1998.82	$0.0199e^{i87}$	$0.0094e^{i313}$	$0.0217e^{i121}$	$0.0115e^{i161}$	$0.0145e^{i263}$	[$0.0060e^{i36}$]	$0.0165e^{i134}$	$0.1099e^{i332}$	$0.0230e^{i151}$	$0.0840e^{i265}$
1998.92	$0.0155e^{i70}$	$0.0141e^{i312}$	$0.0333e^{i114}$	$0.0150e^{i154}$	[$0.0078e^{i350}$]	$0.0078e^{i321}$	$0.0092e^{i108}$	$0.1215e^{i326}$	$0.0237e^{i136}$	$0.0724e^{i250}$
1999.03	$0.0102e^{i105}$	$0.0151e^{i288}$	$0.0242e^{i109}$	$0.0170e^{i156}$	$0.0100e^{i296}$	$0.0057e^{i251}$	$0.0149e^{i74}$	$0.1178e^{i326}$	$0.0206e^{i155}$	$0.0647e^{i257}$
1999.12	$0.0168e^{i111}$	$0.0133e^{i280}$	$0.0234e^{i124}$	$0.0173e^{i160}$	$0.0096e^{i242}$	[$0.0122e^{i116}$]	[$0.0156e^{i160}$]	$0.1202e^{i318}$	$0.0239e^{i151}$	$0.0722e^{i261}$
1999.21	$0.0163e^{i86}$	$0.0092e^{i289}$	$0.0209e^{i145}$	$0.0199e^{i139}$	$0.0086e^{i292}$	$0.0196e^{i214}$	$0.0213e^{i134}$	$0.1049e^{i323}$	$0.0211e^{i135}$	$0.0839e^{i258}$

[a] Values are given in complex form, with phases in degrees

[b] Values in brackets should be regarded as unreliable since they have large uncertainties

Table 5. 43 GHz VLBA D-Terms[a]

Epoch	BR	FD	HN	KP	LA	MK	NL	OV	PT	SC
					Right Circular Polarization					
1997.86	$0.0457e^{i6}$	[$0.0214e^{i306}$][b]	$0.0638e^{i303}$	$0.0232e^{i316}$	$0.0648e^{i138}$	$0.0182e^{i345}$	[$0.0160e^{i111}$]	$0.0196e^{i282}$	$0.0200e^{i11}$	$0.0202e^{i321}$
1997.94	$0.0492e^{i19}$	$0.0119e^{i340}$	$0.0604e^{i306}$	$0.0200e^{i342}$	$0.0693e^{i129}$	$0.0154e^{i355}$	$0.0484e^{i80}$	$0.0219e^{i289}$	[$0.0170e^{i67}$]	$0.0035e^{i288}$
1998.03	$0.0593e^{i15}$	$0.0205e^{i348}$	$0.0669e^{i281}$	$0.0258e^{i354}$	$0.0658e^{i120}$	$0.0044e^{i18}$	$0.0410e^{i64}$	$0.0179e^{i304}$	$0.0288e^{i28}$	$0.0058e^{i169}$
1998.10	$0.0637e^{i21}$	$0.0197e^{i343}$	$0.0679e^{i303}$	$0.0253e^{i347}$	$0.0713e^{i124}$	$0.0106e^{i349}$	$0.0399e^{i77}$	$0.0286e^{i5}$	$0.0208e^{i18}$	$0.0007e^{i240}$
1998.19	$0.0544e^{i24}$	$0.0279e^{i3}$	...	$0.0351e^{i4}$	$0.0709e^{i119}$	$0.0194e^{i57}$	...	$0.0226e^{i14}$	$0.0353e^{i33}$	[$0.0165e^{i324}$]
1998.27	$0.0345e^{i32}$	$0.0149e^{i10}$	$0.0593e^{i317}$	$0.0213e^{i6}$	$0.0756e^{i135}$	$0.0220e^{i30}$	$0.0416e^{i93}$	[$0.0090e^{i202}$]	$0.0253e^{i47}$	$0.0012e^{i217}$
1998.35	$0.0399e^{i25}$	$0.0178e^{i8}$	$0.0539e^{i309}$	[$0.0331e^{i115}$]	$0.0274e^{i26}$	$0.0269e^{i49}$	$0.0351e^{i89}$	[$0.0099e^{i192}$]	$0.0219e^{i38}$	$0.0058e^{i272}$
1998.44	$0.0454e^{i25}$	$0.0261e^{i20}$	$0.0568e^{i325}$	$0.0295e^{i15}$	$0.0272e^{i29}$	$0.0119e^{i47}$	$0.0436e^{i80}$	$0.0063e^{i35}$	$0.0284e^{i41}$	$0.0064e^{i289}$
1998.53	$0.0608e^{i27}$	$0.0231e^{i359}$	[$0.0609e^{i33}$]	$0.0325e^{i2}$	$0.0259e^{i20}$	$0.0319e^{i15}$	$0.0395e^{i115}$	[$0.0091e^{i139}$]	$0.0254e^{i33}$	[$0.0330e^{i135}$]
1998.62	$0.0463e^{i14}$	$0.0203e^{i346}$	$0.0746e^{i298}$	$0.0263e^{i350}$	$0.0206e^{i18}$	[$0.0140e^{i87}$]	$0.0283e^{i81}$	$0.0873e^{i258}$	$0.0205e^{i29}$	[$0.0235e^{i352}$]
1998.71	$0.0537e^{i11}$	$0.0297e^{i324}$	$0.0728e^{i300}$	[$0.0113e^{i267}$]	$0.0252e^{i351}$	$0.0469e^{i24}$	$0.0243e^{i65}$	$0.0644e^{i280}$	$0.0237e^{i12}$	$0.0010e^{i254}$
1998.82	$0.0458e^{i17}$	$0.0220e^{i356}$	$0.0744e^{i298}$	[$0.0104e^{i90}$]	$0.0255e^{i24}$	$0.0055e^{i314}$	$0.0237e^{i79}$	$0.0452e^{i257}$	$0.0218e^{i24}$	[$0.0262e^{i233}$]
1998.92	$0.0480e^{i3}$	$0.0191e^{i321}$	$0.0709e^{i300}$	$0.0269e^{i333}$	$0.0268e^{i22}$	$0.0228e^{i347}$	$0.0345e^{i75}$	$0.0343e^{i243}$	[$0.0284e^{i53}$]	...
1999.03	$0.0242e^{i18}$	$0.0150e^{i344}$	$0.0574e^{i318}$	$0.0221e^{i358}$	$0.0198e^{i29}$	$0.0175e^{i4}$	$0.0416e^{i97}$	$0.0136e^{i357}$	$0.0197e^{i40}$	[$0.0085e^{i139}$]
1999.12	$0.0291e^{i13}$	$0.0126e^{i347}$	$0.0700e^{i298}$	$0.0158e^{i3}$	[$0.0188e^{i66}$]	$0.0242e^{i53}$	$0.0359e^{i108}$	$0.0172e^{i343}$	[$0.0089e^{i9}$]	[$0.0079e^{i92}$]
1999.21	$0.0515e^{i35}$	$0.0286e^{i4}$	$0.0652e^{i311}$	$0.0246e^{i3}$	$0.0216e^{i117}$	$0.0165e^{i11}$	$0.0255e^{i92}$	[$0.0149e^{i190}$]	$0.0204e^{i52}$	[$0.0231e^{i53}$]
					Left Circular Polarization					
1997.86	$0.0594e^{i122}$	$0.0278e^{i264}$	$0.0514e^{i241}$	$0.0232e^{i165}$	$0.0630e^{i57}$	$0.0306e^{i168}$	[$0.0034e^{i192}$]	[$0.0130e^{i24}$]	$0.0337e^{i290}$	$0.0159e^{i209}$
1997.94	$0.0694e^{i126}$	$0.0150e^{i264}$	$0.0487e^{i232}$	$0.0279e^{i157}$	$0.0913e^{i63}$	$0.0134e^{i171}$	$0.0141e^{i117}$	$0.0033e^{i155}$	$0.0205e^{i304}$	$0.0306e^{i17}$
1998.03	$0.0737e^{i127}$	$0.0167e^{i250}$	$0.0543e^{i238}$	$0.0312e^{i163}$	$0.0825e^{i70}$	$0.0333e^{i152}$	$0.0107e^{i125}$	$0.0102e^{i135}$	$0.0215e^{i308}$	$0.0264e^{i11}$
1998.10	$0.0762e^{i123}$	$0.0188e^{i259}$	$0.0478e^{i236}$	$0.0297e^{i161}$	$0.0792e^{i64}$	$0.0277e^{i174}$	$0.0125e^{i94}$	$0.0191e^{i77}$	$0.0278e^{i303}$	$0.0320e^{i7}$
1998.19	$0.0728e^{i114}$	$0.0170e^{i221}$	...	$0.0414e^{i159}$	$0.0867e^{i69}$	$0.0291e^{i163}$	...	$0.0296e^{i87}$	$0.0156e^{i286}$	$0.0165e^{i360}$
1998.27	$0.0524e^{i100}$	$0.0101e^{i270}$	$0.0449e^{i214}$	$0.0284e^{i136}$	$0.0940e^{i55}$	$0.0148e^{i339}$	$0.0221e^{i79}$	$0.0304e^{i40}$	$0.0198e^{i289}$	$0.0432e^{i14}$
1998.35	$0.0591e^{i106}$	$0.0151e^{i211}$	$0.0343e^{i190}$	[$0.0412e^{i95}$]	$0.0227e^{i173}$	$0.0050e^{i64}$	$0.0205e^{i107}$	$0.0388e^{i48}$	$0.0171e^{i299}$	$0.0285e^{i357}$
1998.44	$0.0601e^{i99}$	$0.0100e^{i239}$	$0.0372e^{i213}$	$0.0366e^{i139}$	$0.0209e^{i153}$	$0.0122e^{i358}$	$0.0191e^{i79}$	$0.0243e^{i62}$	$0.0278e^{i278}$	$0.0188e^{i5}$
1998.53	$0.0450e^{i105}$	$0.0186e^{i258}$	$0.0463e^{i264}$	$0.0318e^{i150}$	$0.0154e^{i174}$	$0.0093e^{i43}$	[$0.0030e^{i36}$]	$0.0430e^{i37}$	$0.0279e^{i289}$	$0.0319e^{i15}$
1998.62	$0.0591e^{i118}$	$0.0143e^{i269}$	$0.0542e^{i248}$	$0.0290e^{i164}$	$0.0171e^{i167}$	$0.0315e^{i284}$	$0.0192e^{i134}$	$0.0641e^{i202}$	$0.0209e^{i304}$	$0.0225e^{i6}$
1998.71	$0.0607e^{i123}$	$0.0320e^{i266}$	$0.0478e^{i249}$	$0.0282e^{i180}$	$0.0240e^{i196}$	[$0.0200e^{i159}$]	[$0.0012e^{i196}$]	$0.0721e^{i215}$	$0.0290e^{i286}$	$0.0304e^{i7}$
1998.82	$0.0405e^{i123}$	$0.0266e^{i259}$	$0.0584e^{i252}$	$0.0405e^{i163}$	$0.0190e^{i187}$	$0.0011e^{i262}$	[$0.0084e^{i231}$]	$0.0311e^{i270}$	$0.0259e^{i280}$	[$0.0199e^{i54}$]
1998.92	$0.0479e^{i127}$	$0.0172e^{i271}$	$0.0551e^{i254}$	$0.0321e^{i165}$	$0.0142e^{i169}$	$0.0106e^{i251}$	$0.0052e^{i149}$	$0.0431e^{i233}$	$0.0302e^{i312}$	...
1999.03	$0.0424e^{i102}$	$0.0246e^{i263}$	$0.0297e^{i245}$	$0.0252e^{i144}$	$0.0094e^{i168}$	$0.0161e^{i320}$	$0.0051e^{i121}$	[$0.0261e^{i114}$]	$0.0243e^{i300}$	[$0.0156e^{i65}$]
1999.12	$0.0390e^{i92}$	$0.0164e^{i272}$	$0.0630e^{i265}$	$0.0211e^{i143}$	$0.0127e^{i148}$	$0.0287e^{i257}$	$0.0308e^{i121}$	$0.0183e^{i166}$	$0.0274e^{i304}$	[$0.0197e^{i59}$]
1999.21	$0.0380e^{i95}$	$0.0193e^{i247}$	$0.0517e^{i228}$	$0.0322e^{i139}$	$0.0411e^{i61}$	$0.0142e^{i258}$	$0.0068e^{i72}$	...	$0.0223e^{i278}$	[$0.0118e^{i168}$]

[a] Values are given in complex form, with phases in degrees

[b] Values in brackets should be regarded as unreliable since they have large uncertainties

Table 6. 22 GHz mean[a]VLBA D-terms

Antenna	RR Amplitude	RR Phase	LL Amplitude	LL Phase
BR	0.0252±0.0068[b]	117± 18[b]	0.0151±0.0063[b]	70± 27[b]
FD	0.0047±0.0041[c]	176± 42[c]	0.0124±0.0060	313± 28
	0.0032±0.0041[d]	28± 64[d]		
HN	0.0304±0.0090	66± 14	0.0198±0.0097	108± 24
KP	0.0183±0.0043	92± 12	0.0130±0.0061	146± 26
LA	0.0150±0.0084	334± 28	0.0143±0.0054	288± 25
MK	0.0126±0.0085	358± 31	0.0081±0.0060	264± 58
NL	0.0230±0.0083	38± 19	0.0117±0.0050	110± 28
OV	0.0759±0.0159[e]	97± 8[e]	0.1338±0.0279[e]	323± 12[e]
	0.0261±0.0066[f]	53± 15[f]	0.1121±0.0096[f]	326± 6[f]
PT	0.0084±0.0060	216± 42	0.0177±0.0060	137± 19
SC	0.0676±0.0121	250± 10	0.0706±0.0084	264± 7

[a]Unreliable values in Table 4 have been excluded when computing the mean values

[b]Mean value for epochs 1997.94 to 1999.21

[c]Mean value for epochs 1997.86 to 1998.53

[d]Mean value for epochs 1998.62 to 1999.21

[e]Mean value for epochs 1997.86 to 1998.44

[f]Mean value for epochs 1998.53 to 1999.21

Table 7. 43 GHz mean[a]VLBA D-terms

Antenna	RR Amplitude	RR Phase	LL Amplitude	LL Phase
BR	0.0464±0.0125	19± 13	0.0548±0.0150	114± 18
FD	0.0198±0.0062	352± 20	0.0180±0.0077	257± 18
HN	0.0643±0.0139	304± 12	0.0459±0.0181	240± 20
KP	0.0244±0.0062	354± 16	0.0299±0.0082	155± 16
LA	0.0691±0.0100[b]	127± 9[b]	0.0824±0.0138[b]	63± 9[b]
	0.0243±0.0045[c]	20± 14[c]	0.0167±0.0054[c]	172± 18[c]
MK	0.0178±0.0126	20± 39	0.0265±0.0082[d]	164± 16[d]
			0.0088±0.0060[e]	8± 39[e]
			0.0157±0.0119[f]	274± 30[f]
NL	0.0348±0.0084	86± 16	0.0140±0.0091	107± 34
OV	0.0146±0.0148[g]	331± 62[g]	0.0222±0.0163[g]	59± 47[g]
	0.0382±0.0333[h]	269± 24[h]	0.0412±0.0315[h]	218± 42[h]
PT	0.0235±0.0065	32± 17	0.0240±0.0066	294± 15
SC	0.0024±0.0033[i]	257± 73[i]	0.0279±0.0078[i]	9± 10[i]

[a]Unreliable values in Table 5 have been excluded when computing the mean values

[b]Mean value for epochs 1997.86 to 1998.27

[c]Mean value for epochs 1998.35 to 1999.12

[d]Mean value for epochs 1997.86 to 1998.19

[e]Mean value for epochs 1998.27 to 1998.53

[f]Mean value for epochs 1998.62 to 1999.21

[g]Mean value for epochs 1997.86 to 1998.53

[h]Mean value for epochs 1998.62 to 1999.21

[i]Mean value for epochs 1997.94 to 1998.71