CELESTIAL REFERENCE COORDINATE SYSTEM OF VLBI WITH US-JAPAN JOINT VLBI EXPERIMENTS

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ABSTRACT. The right ascension of 3C273B has been a reference of the celestial VLBI coordinate system. However it seems that 3C273B is inadequate for the reference because 3C273B has the jet component which was detected on long baselines in our experiments. We present the best reference source for celestial coordinate system. Next we estimated the source positions, taking the new reference radio source. The nutation and plate motion were considered in our analysis. We show the change of 3C273B position. The estimated source positions are compared with those given in GSFC source catalog (1985).

1. The movement of 3C273B Jet component

The structure of 3C273B(1226+023) given by Readhead (1) is shown in Figure 1. The arrow in the center shows the movement of the jet component observed in our experiments. The jet component moved about 2 milli arcsec since 1984. The component causes the change of the apparent source position. The right ascension of 3C273B has been the reference of celestial VLBI coordinate system. However it is inadequate for the reference of VLBI coordinate system since the source has the jet component.

2. New reference source

We select the new reference source from the radio sources observed in our experiments. The ideal VLBI source should have following two aspects.

First; it does not have structure and its apparent position does not change.

Second; its declination is near 0 degree.

We checked up the correlation amplitudes in order to select the reference source.

A. K. Babcock and G. A. Wilkins (eds.), The Earth's Rotation and Reference Frames for Geodesy and Geodynamics, 83–89.

Table-1 shows the variations of the correlation amplitudes from January 1984 to September 1985 on Kashima-Mojave baseline. That baseline is about 8000km in length and toward east-west direction. The noise on the correlation amplitudes are estimated to be less than 5%. Therefore the source whose variation in correlation amplitude is larger than 10% may be resolved and inadequate for the reference source.

We checked the baseline dependency of correlated amplitudes. The ratios between the mean correlated amplitude on Kashima-Mojave and Kauai-Mojave baseline in Wpac 1984 or 1985 are multiplied by the ratios of the sensitivity for each station as follows.

$$\text{RATIO}=\frac{\text{Amplitude on Kashima-Mojave baseline}}{\text{Amplitude on Kashima-Mojave baseline}}\times\frac{\text{Sensitivity of Kauai}}{\text{Sensitivity of Kashima}}$$

When the structure is resolved on the long baseline, the ratio becomes smaller than 1. Table-2 shows the ratios of each sources. The ratios of 3C273B and some sources are much smaller than 1. They are resolved sources. The ratios of 0229+131 and some sources are near 1. They are unresolved sources.

0229+131, 2145+067 and 1548+056 are selected as unresolved sources near 0 degree declination. The difference of 0229+131 amplitudes between 1984 and 1985 experiments is smallest among them. After all, 0229+131 is suitable for new reference source of VLBI coordinate system.

3. Nutation and Station Position

In order to estimate the source position accurately, we need to pay much attention to nutation correction and the terrestrial coordinate system. So we discuss the nutation and plate motion to estimate source positions.

The movement of some stations on the Pacific-plate is measured within about 1 cm/year. We used the station position predicted by the measured movement for each experiment. The measured movement agreed well with the predicted movement.

Next we check the nutation. The difference between the nutation of Wahr model and the nutation estimated by us is larger than 2 milli arcsec in some experiments. That behavior seems to have annual periodic variation. The new nutation correction is proposed by Herring and others. When the periodic terms of Herring correction shorter than one year are included in our analysis, the periodic behavior of nutation shorter than one year is removed. The weighted r.m.s. of the difference between Herring and our estimated value is smaller than 1 milli arcsec. The offset of obliquity nutation is about 0.8 milli arcsec. The offset may be caused by the long periodic term of Herring correction which we do not include in our results. The nutation values estimated in CDP VLBI network are consistent with the Herring nutation correction obtained by IRIS network. Therefore we can use the estimated values in the analysis of the source positions.

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4. The change of 3C273B position

The observed position of 3C273B is the weighted mean of whole emission region and Jet component. Figure 2 shows the 3C273B position for every experiment taking 0229+131 as the reference source. The upper figure is the estimated right ascension and the lower figure is the estimated declination. The ordinate is time. The changing rates of right ascension and declination are -0.8+0.8milli arcsec/year and 0.2+0.6milli arcsec/year respectively. The change of 3C273B position is consistent with the position change derived from the correlation amplitude.

5. Source positions

Table-3 shows a part of our source position catalog. The reference of right ascension is 0229+131. The source positions are obtained by the weighted mean of the positions for every experiments in order to check the repeatability. The source position by this method is the ensemble mean of experiments. The errors of the source position were about 0.3 milli arcsec.

Figure 3 shows the differences between GSFC catalog (1985) and estimated source position observed in the US-Japan joint VLBI experiments since 1984. The upper figure is the difference of right ascension between source position of our catalog and GSFC catalog, and lower figure is that of declination. The ordinate is the right ascension of radio sources. The difference of the declination behaves like sinusoid curve. This behavior may be caused by the nutation error. We compared the JPL catalog with GSFC catalog. We can see the same behavior of declination in this figure.

6. Conclusions

1: The position of 0229+131 is adopted as the reference of celestial VLBI coordinate system instead of the position of 3C273B.

2: The nutation values estimated by us agrees with the Herring correction derived from IRIS data. We can use the estimated values of nutation in our analysis of source positions.

3: The movement of 3C273B position are consistent with the position change derived from correlation amplitudes.

4: We estimate the source position by considering the nutation correction and plate motion. The difference of declination between our estimated source positions and GSFC catalog behaves like sinusoidal curve although the r.m.s. is smaller than 1 milli arcsec.

Reference

(1) A.C. Readhead, et al., 'Bent beams and the overall size of extragalactic radio sources',Nature, Vol 276, P768, Dec. 1978.

SOURCE NAME	VARIATION OF CORRELATED AMPLITUDE	NUMBER OF EXP.	COMMENT
0229+131	7.2%	14	Reference Source
2145+067 1548+056	8.1% 8.9%	13 14	Point Source
OJ287 0552+398 0106+013 0234+285 1803+785 4C39.25	9.1% 9.6% 10.9% 15.2% 15.9% 20.3%	11 19 12 15 13 16	Point or Resolved Source ?
3C454.3 3C273B 3C345	18.8% 19.1% 30.6%	18 19 19	Resolved Source

Table 1 The variation of correlation amplitudes

SOURCE NAME	1984	1985	COMMENT
0229+131	0.87	0.74	Reference Source
2145+067 1548+056	0.82 0.91	0.73 0.88	Point Source
0552+398 0106+013 0234+285 4C39.25	0.67 0.39 0.92 0.75	0.51 0.63 0.78 0.72	Point or Resolved Source ?
3C273B 3C345 3C454.3	0.21 0.61 0.27	0.22 0.46 0.52	Resolved Source

Table 2 Baseline dependency of correlation amplitudes

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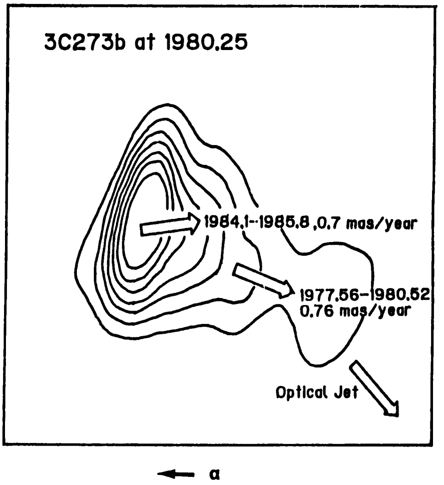

Figure 1 The movement of 3C273B Jet Component

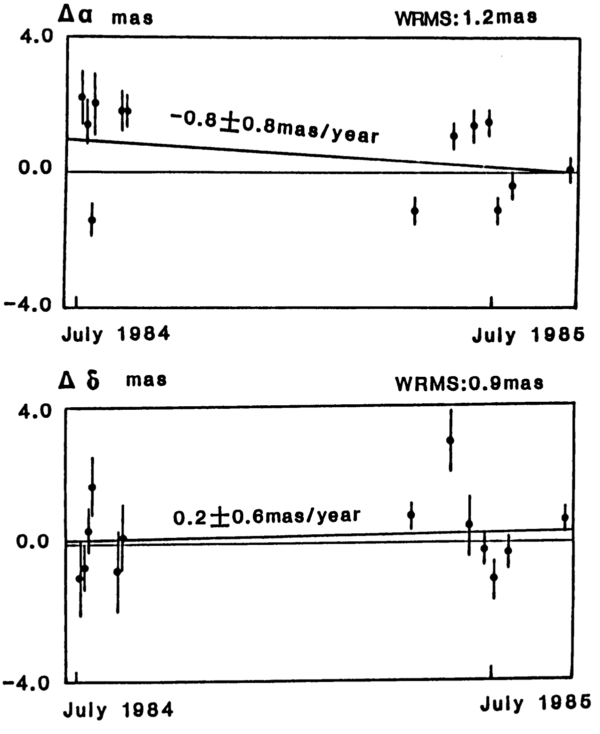

Figure 2 The change of 3C273B apparent position

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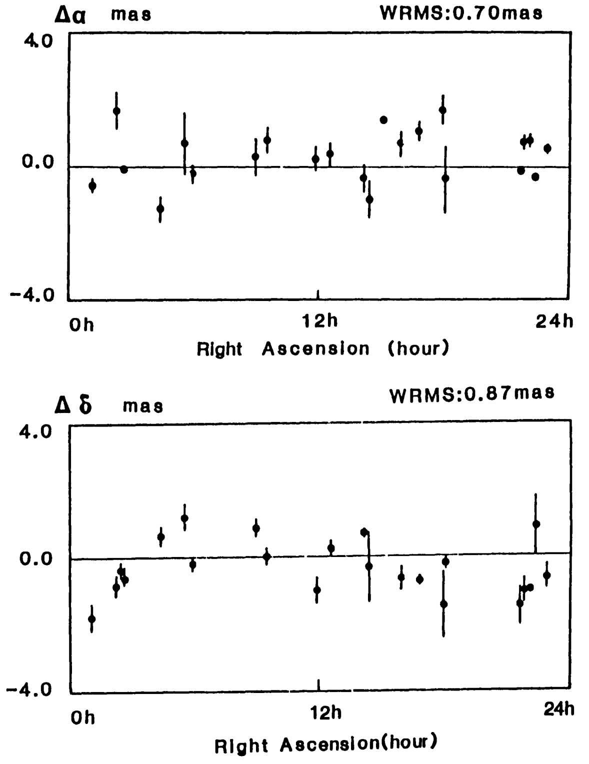

Figure 3 The difference between estimated source positions and GSFC catalog

Source Name	Right Ascension HH	MM	SS.SSSSS	Error(ms)	Declination DD	MM	SS.SSSS	Error(mas)	Number of data	Number of EXP
0106+013	1	8	38.77107	0.01	1	35	0.3188	0.4	472	11
0234+285	2	37	52.40572	0.01	28	48	8.9910	0.3	826	10
0229+131	2	31	45.89410	–	13	22	54.7182	0.3	870	13
0552+398	5	55	30.80567	0.02	39	48	49.1658	0.2	1370	13
4C39.25	9	27	3.01394	0.03	39	2	20.8520	0.3	999	10
3C273B	12	29	6.69973	0.02	2	3	8.6003	0.3	937	13
1548+056	15	50	35.26918	0.03	5	27	10.4501	0.4	737	10
3C345	16	42	58.80995	0.02	39	48	36.9940	0.2	1468	13
1803+784	18	0	45.68385	0.07	78	28	4.0181	0.2	1627	11
2145+067	21	48	5.45864	0.01	6	57	38.6048	0.4	639	11
3C454.3	22	53	57.74796	0.01	16	8	53.5623	0.4	1000	13

Table 3 The estimated source positions

DISCUSSION

Johnston: I have a question for C. Ma. In his extensive VLBI data set, does he see any motions in other sources such as 3C345?

Reply by Herring: We examined 3C345 and see a small rate in RA of ~0.1 mas/yr for about 2 years, which was consistent with the superluminal velocity of the "jet" as it is ejected from the core. The uncertainty of the rate estimate is probably about 0.05 mas/yr.