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IV. EXPERIMENTAL RESULTS

IV.7 THE RESULTS OF TEST VLBI EXPERIMENTS WITH THE SYOWA STATION IN ANTARCTICA

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ABSTRACT

The position of Syowa Station in Antarctica was measured with an error on the order of decimeters by a Very Long Baseline Interferometer (VLBI) experiment carried out in January 1990. This was the first VLBI experiment connecting Antarctica with other continents. Kashima, Japan and Tidbinbilla, Australia participated in the experiment in conjunction with Syowa Station. The K-4 data acquisition terminal used at Syowa Station was transported from Kashima for temporary use. The data obtained at Syowa Station and Tidbinbilla were brought to Kashima for data processing, where a data were correlated and analyzed to obtain a precise position of Syowa Station. This paper outlines the experiments and describes the results of the baseline analysis.

1. Introduction

Geodetic VLBI stations are mainly distributed in the northern hemisphere, but it is important to extend the networks to the southern hemisphere not only for measuring precise plate motion but also for monitoring earth rotation. Although many efforts have been made to establishing new VLBI stations in the southern hemisphere, no VLBI experiment had been conducted with an Antarctic station until the first experiment reported here due to the unavailability of antennas for VLBI experiments. In 1989, the 30th Japanese Antarctic Research Expedition (JARE-30) organized by the National Institute of Polar Research (NIPR) in Japan, built a multipurpose satellite data receiving antenna 11 m in diameter at Syowa Station (69.0S, 39.6E) in Antarctica.(1) This antenna is also designed for VLBI and radio astronomy. Figure 1 shows the position of Syowa Station in Antarctica. The Communications Research Laboratory (CRL) in Japan conducted test VLBI experiments between the 11-m antenna at Syowa Station and the 26-m antenna at Kashima (35.8N, 140.7E) in Japan in January 1990 in cooperation with JARE-30. The main purpose of the test experiments was detection of the fringes in order to check the feasibility of future Antarctic VLBI experiments. A 34-m antenna at Tidbinbilla (35.2S, 149.0E), Australia, also participated in the experiments to improve the limited mutual visibility.

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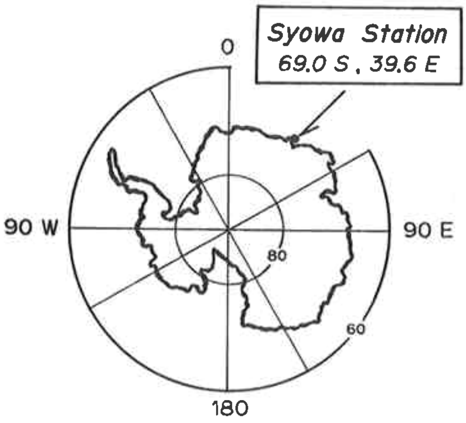

Fig. 1 The Antarctic Continent and position of the Syowa Station.

2. Experiments

2.1 Environment of the Experiments and Instruments

The experiment was scheduled to be carried out within a month during the yearly exchange of personnel at Syowa Station in austral summer. All equipment necessary for the VLBI experiment was transported to Syowa Station by members of JARE-31 and the Japanese ice-breaker "Shirase".

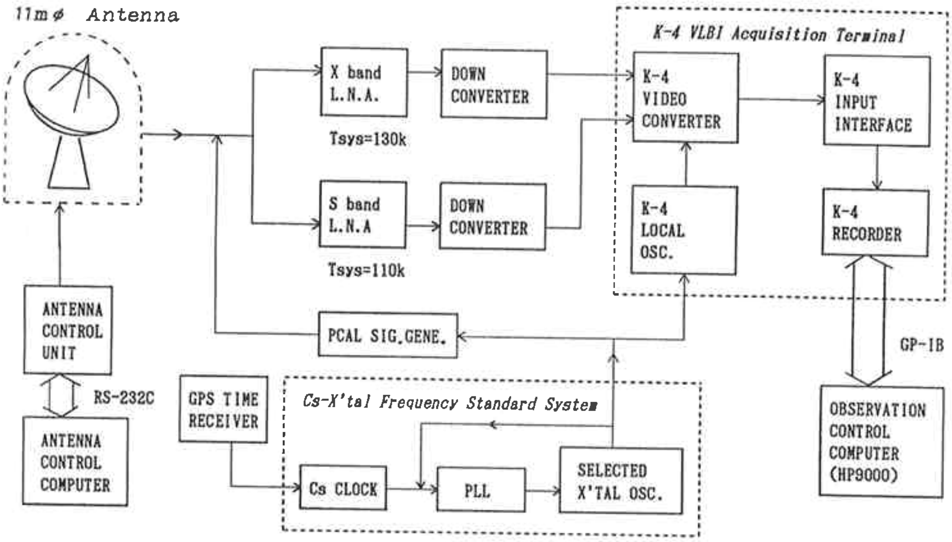

Fig. 2 Block diagram and signal flow of the data acquisition system at Syowa Station.

In these experiments, newly developed and highly transportable "K-4" recorders dedicated to VLBI data acquisition [2],[3] were employed at both Syowa Station and Kashima. By adopting a helical scanning head with a 3/4-inch wide cassette tape, the K-4 recorder is much more compact (approximately one-fourth in both size and weight) compared with conventional K-3 or Mark-III recorders used for VLBI. Consequently, the K-4 recorder can be easily transport and operated. It would have been virtually impossible to perform the experiment without this transportable K-4 recorder at Syowa Station.

Moreover, use of a highly stable crystal oscillator as a frequency standard at Syowa Station with its phase locked to a cesium clock[4] enabled us to perform the experiment promptly, this in spite of the lack of a transportable H-maser oscillator. Figure 2 shows a block diagram and the signal flow of the data acquisition system at Syowa Station. Clock synchronization at the microsecond level at Syowa Station, which is necessary for correlation processing, was achieved by both a GPS receiver and a portable clock technique using the cesium clock transported from Japan.

2.2 Observations

A total of three experiment sessions were carried out in January 1990 according to the schedule shown in Table 1. One session is here defined to be a set of scans, where one scan observes a radio source (quasar) for 196 sec. We used the 31 radio sources listed in Table 2. The first session was a rehearsal session consisting of 12 scans and was performed on January 16 between Kashima and Syowa Station. The second and third sessions were carried out on January 20 and 25 and lasted for about 24-hours in which more than 150 scans were made. In these latter two sessions, Tidbinbilla

Table 1 Schedule of the test VLBI experiments

Exp. Name	Date	Time (UT)	Station
Initial test experiment	16 Jan. 1990 16 Jan. 1990	09:00–09:30 23:00–23:30	Syowa Kashima
1st 24-hour experiment	20 Jan. 1990 21 Jan. 1990	03:00– 3:30	Syowa Kashima Tidbinbilla
2nd 24-hour experiment	25 Jan. 1990 26 Jan. 1990	19:20– 19:23	Syowa Kashima Tidbinbilla

Table 2 Observed source list of 24-hour VLBI experiments

0104 – 408,	0308 – 611,	0402 – 362,	0420 – 014,	0454 – 234,
0537 – 441,	0607 – 157,	0637 – 752,	0727 – 115,	1034 – 293,
1057 – 797	1101 – 325,	1104 – 445,	1206 – 399,	1226 + 023,
1251 – 713,	1253 – 055,	CENT – A,	1334 – 127,	1424 – 418,
1510 – 089,	1548 + 056,	1549 – 790,	1730 – 130,	1741 – 038,
1831 – 711,	1921 – 293,	2134 + 00,	2145 + 067,	2223 – 052,
2355 – 534				

Table 3 Performance of the receiving system at the Syowa Station

Distance from Kashima:	11400 km
Antenna Diameter:	11 m
Random Diameter:	17 m
Receiving Frequency	
S band:	2200–2320 MHz
X band:	7860–8600 MHz
Aperture Efficiency	
S band:	57%
X band:	59%
System Noise Temperature	
S band:	111 k
X band:	126 k
Fringe Detectability	
S band:	1.77×10^{-4}Jy^{-1}
X band:	1.61×10^{-4}Jy^{-1}

participated to reduce restrictions on observation arising from very limited mutual visibility for the Kashima-Syowa Station baseline, which is the longest VLBI baseline (about 11400 km) on the earth at present. The quasar signals were recorded on dual frequency bands (S band: 2 GHz and X band: 8 GHz) at each station in order to calibrate ionospheric excess delays. Table 3 summarizes the performance of the antenna and receiving system at Syowa Station.

2.3 Correlation Processing

The "Shirase" brought back the observation data from Syowa Station in April 1990. The data were cross-correlated at the Kashima K-3 correlator immediately in order to form observables such as delay time, delay rate and fringe amplitude. Delay time is defined as the time difference between the arrival of a certain wave front at one end of a baseline and its arrival at the other end. Delay rate is rate of change of the delay time. By correlating two station's data, good fringes were detected on both S and X band (one of them is shown in Fig. 3). In order to correlate the data obtained with different recording systems, i.e., the K-4 and Mark-III types, new correlating software had to be developed.

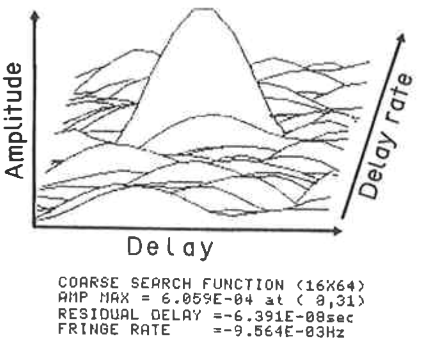

Fig. 3 The detected fringe on X band from 3C273B for Syowa Station-Kashima baseline.

2.4 Analysis and Geodetic Results

After correlation processing, the positions of Syowa Station and Tidbinbilla were obtained by means of parameter adjustment in a least squares estimation(5) using the delay observables. By this estimation, the position of Kashima was fixed on January 20, 1990 at -3997890.354 m, 3276580.512 m, and 3724118.800 m (x, y, and z components, respectively) in the VLBI coordinate system(6). The major radio source positions were also fixed at the values given by the VLBI group at Goddard Space Flight Center, NASA(7). However, some of the source positions in the southern hemisphere, which are not included in the radio source catalog of the GSFC VLBI group, were adjusted in the analysis. Other than the above, the least squares analysis here was essentially identical to the usual international procedure for geodetic VLBI data analysis(8). The positional coordinates obtained for the stations are summarized in Table 4, together with their one-sigma formal errors.

Table 4 Position of Syowa Station and Tidbinbilla obtained by the VLBI experiment in January 1990

Station		1st 24-hour experiment (20 January)	2nd 24-hour experiment (25 January)
Syowa Station	x	1766198.06 +/– 0.08 m	1766197.93 +/– 0.08 m
	y	1460404.00 +/– 0.08 m	1460403.91 +/– 0.08 m
	z	–5932268.45 +/– 0.17 m	–5932268.17 +/– 0.18 m
Tidbinbilla	x	–4460933.56 +/– 0.05 m	–4460933.47 +/– 0.06 m
	y	2682764.82 +/– 0.03 m	2682764.77 +/– 0.04 m
	z	–3674381.21 +/– 0.06 m	–3674380.92 +/– 0.07 m

2.5 Discussion

The adjusted results show considerably larger errors than those common in current geodetic VLBI experiments, especially in the z-component of the Syowa Station position. This is thought to be due to an observing schedule unsuitable for Precise geodesy, that is, imperfect sky coverage of the observed sources. Participation of Tidbinbilla was intended to improve the limited mutual visibility. This was not entirely successful, in part because of machine time restrictions on the Tidbinbilla antenna (approximately 15 hours for the session on January 20 and 21 hours for that on January 25), and partly because of the imperfect radio source catalog in the southern hemisphere (we had to use the sources in a limited declination range). Unsuitable observing schedules, especially in the case of limited sky coverage, elongate the error ellipsoid of estimated station positions in the baseline direction. Furthermore, the errors in vertical components are usually larger than those in horizontal components. Both of these effects increase the error in the positions z-component, especially that of Syowa Station. Another possible contribution to the larger errors is the inferior stability of the frequency standard at Syowa Station compared to the H-maser oscillators used at other stations.

Figure 4 shows the station locations and baseline lengths obtained by the above VLBI experiment in January 1990.

3. Conclusion

We have presented the results of a test VLBI experiment, the first with an Antarctic station. We successfully obtained many good S and X band fringes on the baselines between Syowa Station in Antarctica, Kashima in Japan and Tidbinbilla in Australia. From the delay observations we determined the position of Syowa Station in Antarctica with an estimated error less than 8 centimeters for the x and y components and less than 18 centimeters for the z component. Although the station positions derived from the experiment have larger errors than those in a conventional geodetic VLBI experiment, we can conclude that this first VLBI experiment connecting Antarctica with other continents was successful. The results will serve as initial values for future measurements of the Antarctic plate by a fixed VLBI system.

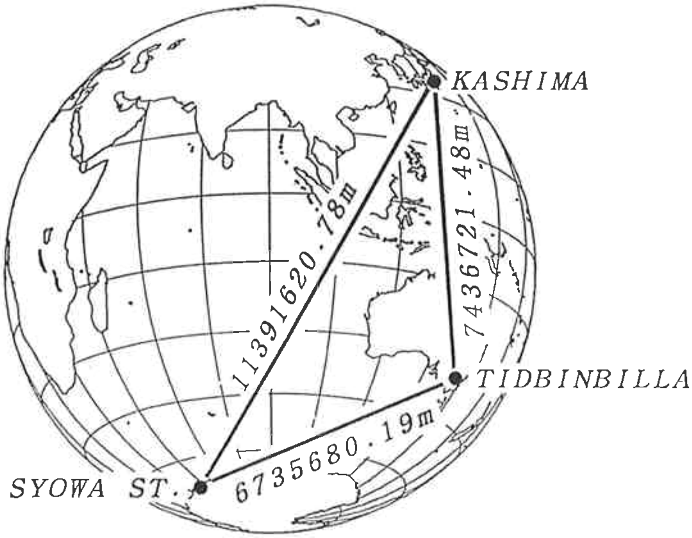

Fig. 4 The station configuration and baseline lengths obtained by test VLBI experiments.

Acknowledgements

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