Astrophysical Phenomena Revealed by Space VLBI
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A 22 GHz Line Radiometer for the Usuda Tracking Station

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Abstract

Differential measurements of atmospheric water vapor line emissions measured with spaced radiometers, usually mounted on the antenna of a millimeter-wave interferometer, can be used to correct for tropospheric phase errors in the interferometric observations. In this report, we describe a novel method to compare the tropospheric phase fluctuations with 22 GHz water vapor line emissions along a single line of sight. With this method, we can investigate the direct relation between the tropospheric path delay and water vapor line emissions at various elevation angles.

1 Introduction

Atmospheric phase fluctuations due to the water vapor content of the lower atmosphere are one of the most serious problems for millimeter-wave VLBI and/or submillimeter-wave radio synthesis arrays. Radiometric phase correction is one of the promising methods for improving the coherence of the fringe phases. In this method, a radiometer is mounted on a radio telescope to measure the amount of water vapor along a line of sight. An example of the successful application of this method is described by Marvel and Woody (1998).

One of the interesting applications of the radiometric method is the determination of the scale factor to transfer the brightness of the water vapor to the quantity of the phase shift at the observing frequency. Since the scale factor is depends greatly on the atmospheric temperature, pressure, humidity, and elevation angle, it is quite difficult to obtain the factor from ground weather conditions at an antenna site.

The frequency standard of HALCA is transferred from a ground tracking station (Suzuki et al. 2000). Since the transferred phase is returned from the satellite to the tracking station, the atmospheric phase fluctuation along a single line of sight can be studied (Kawaguchi 1998). If a radiometer is installed on a HALCA tracking station, the direct relation between the tropospheric path delay and water vapor line emissions at various elevation angles and under various weather conditions can be investigated. In this report, we introduce our study for the development of the fringe phase correction using HALCA and the tracking station at Usuda, Japan.

2 Water Vapor Line Monitor

2.1 Instruments

The radiometer under development consists of two sections. One is an RF section to amplify a received signal at 18–26.5 GHz and then down-convert it. Since, in tracking HALCA, a link antenna transmits the up-link signal at 15.3 GHz with the level of 14 dBm, there is a possibility of causing saturation of the first LNA. Therefore, a wave guide with a high pass filter is inserted between a horn and the LNA to cut microwave power at less than 16 GHz. The received signal is down-converted to 3–11.5 GHz and transmitted to another section (IF section), which divides the signal into eight frequency channels each 900 MHz wide to obtain the line shape of the water vapor emission. The frequency table is listed in Table 1 with the equivalent receiver noise temperature.

2.2 Test Observations

We have conducted test observations with the radiometer. The time variation of the brightness difference, observing at the zenith, obtained by $T_{sky4} - (T_{sky1} + T_{sky8})/2$ is shown in Figure 1, where T_{sky1}, T_{sky4}, and T_{sky8} are the equivalent sky noise temperatures of frequency channels 1, 4, and 8, respectively.

3 Schedule

We will install our radiometer on the Usuda tracking station antenna in March, 2000. The radiometer will be mounted close to the Cassegrain focus of the 10 m dish to illuminate the sub-reflector (Figure 2). The

Table 1: Frequency table of the water vapor radiometer.

Channel	Frequency (GHz)	Receiver Noise Temperature (K°)
1	19.15 – 20.05	219.2
2	20.05 – 20.95	226.3
3	20.95 – 21.85	216.5
4	21.85 – 22.75	193.1
5	22.75 – 23.65	207.5
6	23.65 – 24.55	227.3
7	24.55 – 25.45	230.6
8	25.45 – 26.35	245.3

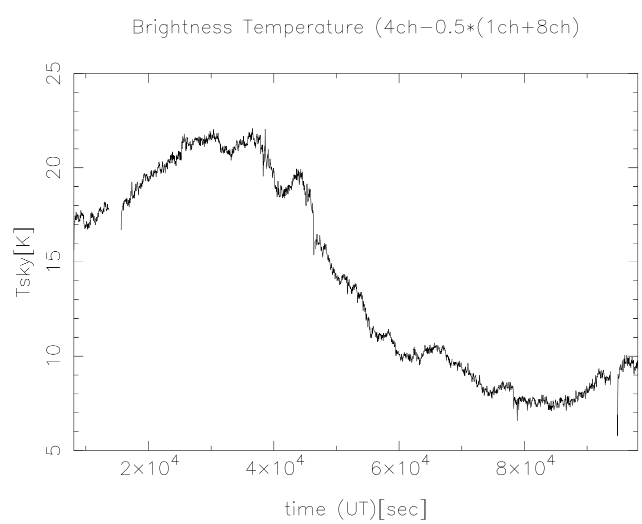

Figure 1: Time variation of the output of the radiometer.

Figure 2: Radiometer mounted on the Usuda 10 m dish for tests. It was then unmounted to conduct further tests in the laboratory.

offset angle between the lines of sight of the tracking antenna and the radiometer is 0.6°, which corresponds to a spatial distance of 11 m at 1 km. The purpose of this study is to investigate the relation between the weather conditions and elevation angles, and the brightness due to the tropospheric water vapor.

Since it will be technically more difficult to control position switching with a larger antenna and at higher frequencies than HALCA, position switching may not be fast enough to carry out phase-referencing for future space-VLBI missions. Therefore, the radiometric phase correction will be important to conduct future space-ground VLBI requiring phase correction techniques.

References

Kawaguchi, N., Ph D thesis, Graduate University of Advanced Studies of Japan, 1998,

Suzuki, K., Kawaguchi, N., & Kasuga, T., 2000, *these Proceedings*

Marvel, K.B., & Wooday, D.P. 1998, in Proceedings of SPIE, **3357**, ed. I.G. Phillips, 442