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6.7 GHz Methanol Masers Observation with Phased Hitachi and Takahagi

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Abstract. For the high-sensitivity 6.7 GHz methanol maser observations, we developed a new technology for coherently combining the two signals from the Hitachi 32 m radio telescope and the Takahagi 32 m radio telescope of the Japanese VLBI Network. Furthermore, we compared the SNRs of the 6.7 GHz maser spectra for two methods. One is a VLBI method and the other is the newly developed digital position switching, which is a similar technology to that used in noise-cancelling headphones. We report the phase-up technique and the observation.

Keywords. instrumentation: spectrographs techniques: interferometric

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1. Introduction

The establishment of a synthesis technology using two signals from two stations with a maser observation as a reference is our first goal. Once this technology is realized, the phase difference of the synthesis parameters can be determined by the maser observation with two antennas. As a result, the observation efficiency is expected to improve. Moreover, in the case of spectral observation, the position switching of a single dish is performed by moving the antenna physically. Then, the system noise and other background noises can be removed and only the maser signal will remain. Once two antennas are phased, it is expected to create a virtual-off source by changing the phase of the synthesis parameters similarly to noise-cancelling headphones. Without physically moving the antenna, the digital position switching observation is considered to be performed. This is the second goal of our research.

2. Parameters for phasing two radio telescopes by maser observation

If we define P_a as the signal power of antenna A and P_b as the signal power of antenna B, then P_{sum}, the signal power after combining antennas A and B with phase difference $\Delta\theta$, can be expressed as

$$P_{sum} = |P_a + P_b| = \sqrt{P_a^2 + P_b^2 + 2P_aP_b \cos\Delta\theta}. \quad (2.1)$$

The maximum value of the combined signal is $P_a + P_b$ and the minimum value is $P_a - P_b$ (when $P_a \geqslant P_b$). If the signal powers of the two antennas are equal, the power is doubled. However, depending on the phase difference $\Delta\theta$, the signal will decrease and disappear in the worst case. The extinction state can be used as an off-source observation. By adding an offset of 180° to the perfectly matched angle $\Delta\theta$, it can be applied for digital position switching. Figure 1 shows the sample spectra which made by the coherently combined signals of Hitachi 32m and Takahagi 32m. We confirmed the sensitivity (SEFD) by comparison of the daily monitoring result became about 85 Jy, where the SEFD of each telescope was 170 Jy.

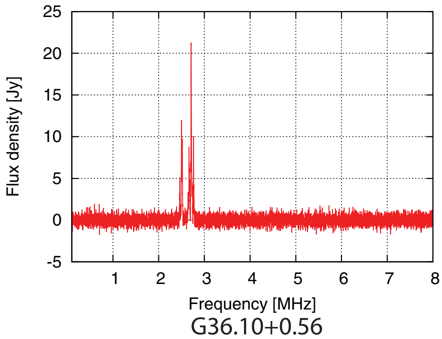

Figure 1. Sample Spectra of phased two telescope of Hitachi 32 m and Takahagi 32 m after digital position switching performed in 60 s integration and 1 kHz resolution.

To determine the phase difference $\Delta\theta$, two methods can be considered,

- Performing the cross-correlation (VLBI) to the maser emission between two antennas and obtain the phase difference [Takefuji *et al.* (2017)]..
- Combining the two signals by adding an offset of 120°, −120°, and 0° and compare the amplitude of the maser emission by performing the cross-correlation spectrometry [Takefuji *et al.* (2016)]. Figure 2 shows the spectra of Hitachi 32 m and Takahagi 32 m by the cross-correlation spectrometry.

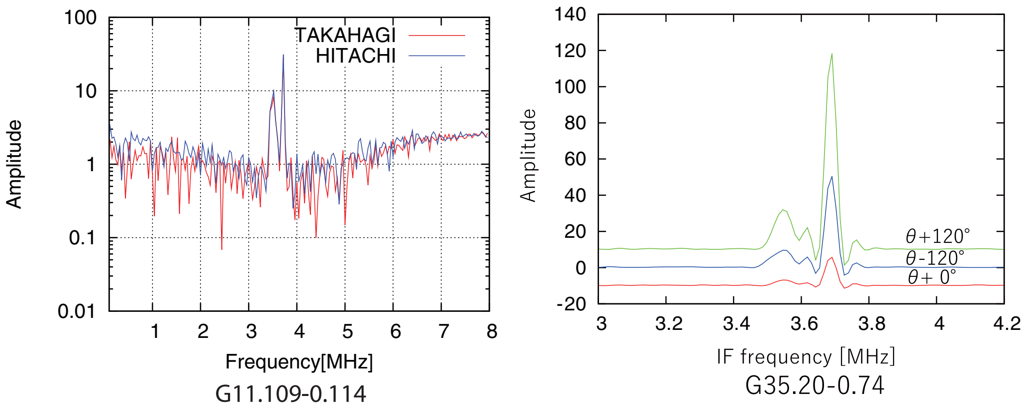

Figure 2. Left: Sample cross-spectra of the observed maser sources with Hitachi 32m and Takahagi 32m by the cross-correlation spectrometry. Right: The phase difference of two telescopes are obtained after comparing the XCS amplitudes of three cases of the phased result by adding an offset of 120°, −120°, and 0°. We added offsets to the plots for a clarity.

References

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