VLBI application for Frequency Transfer and Development of GALA-V System (VII)

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1. Introduction
NICT is conducting a development of the new broadband VLBI system, named GALA-V, for distant frequency comparison. By means of VLBI observations with small diameter VLBI station installed at each of atomic frequency standards to be compared, the frequency of the standard signals are compared. We have developed original broadband feed for Cassegrain type Kashima 34m antenna and enabled observation of celestial radio source in 3-14 GHz frequency range simultaneously. This broadband observation does not only improve the signal to noise ratio of VLBI observation, but also drastically improves delay measurement precision. Our GALA-V system is designed to be compatible with the VGOS (VLBI Global Observing System), which is promoted by the IVS as the next generation geodetic VLBI system, so that GALA-V and VGOS joint observation will be possible. Such collaboration with VGOS stations will be useful for GALA-V to improve the precision of frequency comparison.

2. Super broadband VLBI observation with Ishioka 13m VGOS Geodetic Station and Kashima 34m station
We have made super broadband VLBI experiment between Ishioka 13m VGOS station of GSI and NICT Kashima 34m station with broadband feed (NINJA) in 2015. Then cross correlation data of super broad bandwidth (8 GHz) were synthesized, and precise group delay observable as arrival time difference of radio signal from celestial radio source to the two VLBI stations was determined at sub-pico second (0.1 mm in light velocity) precision by one second of integration time. Although the delay measurement is in great precision, error of geodetic position determination is limited by atmospheric delay estimation error, unless many scans of observable in different direction of the sky are gathered in short time interval via fast slew antennas as required in the VGOS specification. Result of our geodetic VLBI experiment with broadband system between Ishioka 13 m and Kashima 34m stations was following to this expectation. Precision of geodetic position determination is related to measure of frequency comparison precision. Thus we need to investigate strategy to enable quick scan switching observation with the GALA-V.

3. VLBI Frequency Comparison between NMIJ and NICT.
Small diameter antenna systems of GALA-V have been installed at NICT Koganei, where Japan Standard Time (JST) is maintained, and NMIJ, where atomic time standards are developed. This NICT-NMIJ is an excellent test bed to evaluate VLBI system for frequency comparison. By using broadband observation system mentioned above, even small diameter antenna can work as a VLBI station for frequency transfer. Some experiments results with this test bed will be reported in this presentation.

4. Summary

Development of a broadband VLBI system, which is compatible with the VGOS, is being conducted in the GALA-V frequency comparison project. Broadband VLBI experiment conducted between Ishioka 13m VGOS station of GSI and NICT Kashima 34m station has demonstrated sub-pico second delay measurement in one second of integration. This is the highest precision of group delay measurement of microwave technique. NICT and NMIJ are jointly working to evaluate the VLBI application for distant frequency comparison. After verification of this technique, we will plan moving small station to foreign country to for intercontinental frequency comparison.

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Keywords: Very Long Baseline Interferometry(VLBI), VGOS(VLBI Global Observing System), Distant Frequency Comparison

