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

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1. Introduction

NICT is conducting a development of the new broadband VLBI system for distant frequency comparison. This project, named GALA-V, is intended to make precise frequency comparison between atomic frequency standards by VLBI observation of celestial radio sources with 3 ? 14 GHz. Advantages of using VLBI technology with respect to the two way satellite time and frequency transfer (TWSTFT) are simultaneous multi station comparison by single VLBI session and freedom of from availability of communication satellites. Additionally VLBI method is not affected by precision of orbit information of GNSS satellites. From the view point of broadband observation system, ours is semi-compliant with the VGOS (VLBI2010 Global Observing System), which is under development as next generation geodetic VLBI system in international VLBI community. Thus this system is not only useful for distant frequency comparison, but also for precise geodesy.

NICT has originally developed broadband feed for Kashima 34m radio telescope. And small diameter broadband VLBI antennas and data acquisition systems were installed at NICT Koganei and National Metrology Institute of Japan (NMIJ) in Tsukuba, where standard time UTC[NICT] and UTC[NMIJ] are maintained, respectively. By joint use of the 34m antenna and two small antenna systems, measurements of UTC[NICT]-UTC[NMIJ] have been performed.

For contribution to geodesy, we have made a series of test experiments between Ishioka VGOS station, which is established by GSI in 2014, and Kashima 34m antenna. In January 2015, we have successfully observed super broadband signal over 8GHz frequency range and cohelently synthesized for the first time. Additionally, the first international broadband VLBI experiment was successfully performed among Kashima 34m, Westford 18m antenna at MIT Haystack observatory, and GGAO station at NASA/GSFC.

2. 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. Since accurate measurement result of difference between UTC[BIPM] and UTC[NICT], UTC[NMIJ] are regularly reported to BIPM (Bureau International des Poids et Mesures), thus NICT-NMIJ is good test bed for development of VLBI system for frequency comparison. Further long term comparison and employment of broadband system will be tested in this year.

3. Super broadband VLBI observation with Ishioka VGOS Geodetic Station of GSI

The GSI has established a new VGOS 13m diameter antenna (hereafter Ishioka 13m antenna) at Ishioka geodetic station in 2014. This antenna is domestically the second largest telescope with broadband receiver. We have conducted a super broadband VLBI experiments between Kashima 34m antenna and Ishioka 13m antenna. Signal from celestial radio source was observed by six observation bands (1GHz bandwidth) allocated in 6-14GHz frequency range. The data was acquired by newly developed direct-sampling technique. After correlation processing of the data, signal was synthesized coherently over 8GHz bandwidth. This was the first achievement and theoretical delay precision reaches to several tens of femto seconds! Of course precision in real measurement is degrade by a number of causes. Further evaluation of actual delay precision will be made.

4. The First International VLBI Experiment with Broadband Systems.

The GALA-V project is not only developing original new technology such as direct-sampling data acquisition technique, but also keeping compatibility with VGOS system is in the scope for joint international observation. In January 2015, we have successfully made the first international VLBI experiment with broadband feed between Kashima 34m antenna, and Westford 18m

antenna, and GGAO 12m antenna. The observation data were exchanged between Japan and U.S.A. through high speed network of JGN-X, APAN, and Internet2.

Keywords: Very Long Baseline Interferometory, Time and Frequency Transfer