VLBI Measurements for Time and Frequency Transfer

Hiroshi Takiguchi[1]; Yasuhiro Koyama[1]; Ryuichi Ichikawa[1]; Tadahiro Gotoh[2]; Atsutoshi Ishii[1]; Thomas Hobiger[1]; Mizuhiko Hosokawa[3]

[1] KSRC,NICT; [2] NICT; [3] CRL

http://www2.nict.go.jp/w/w114/stsi/index.html

Modern cold-atom-based frequency standards have already archived the uncertainty of 10^{-15} at a few days. Moreover cold-atom-based optical clocks have the potential to realize the uncertainty of from 10^{-16} to 10^{-17} level after a few hours. On the other hand, time transfer precision of two-way satellite time and frequency transfer and GPS carrier phase experiments have reached the 10^{-10}@1sec (10^{-15}@1day) level. In order to compare such modern standards by these time transfer techniques, it is necessary to average over long periods. Since these techniques are not sufficient to compare next standards improvements of high precision time transfer techniques are strongly desired. Space geodetic techniques like VLBI, SLR and GPS are based on precise time measurement using very stable reference signals. VLBI measures the arrival time delays between multiple stations utilizing radio signals from distant celestial radio sources like quasars and pulsars. In the usual geodetic VLBI analysis, clock offsets and their rates of change at each station are estimated with respect to a selected reference station. The averaged formal error (1 sigma) of the clock offsets is typically about 20 picoseconds when analyzing geodetic VLBI experiments which are regularly conducted by the International VLBI Service for Geodesy and Astrometry (IVS). This precision is nearly one order better than other techniques like GPS or two-way satellite time transfer.

In this study we compare time transfer precision between VLBI and GPS carrier phase using the Kashima-Koganei baseline in order to confirm the potential of VLBI time and frequency transfer. VLBI experiments were performed four times (two 24 hour sessions, one 3 days session and one 7 days session) and GPS observations were carried out at the same time sharing common reference signals. The averaged formal error (1 sigma) of the hourly estimated clock offsets as obtained from VLBI analysis was 30 picoseconds. The difference between VLBI and GPS was about +/-500 picoseconds what is considered to be caused by the uncertainty of the GPS time transfer. The results show that VLBI time transfer is more stable than GPS time transfer on the same baseline. We also compare time transfer precision using the Onsala-Wettsell baseline. We used R1 experiments (R1270, R1271, R1273 and R1274 sessions) conducted by IVS and the International GNSS Service (IGS) stations (ONSA and WTZR) data. The results show more clearly that VLBI time transfer is more stable than GPS time transfer on the same baseline and same period. In general, the VLBI time transfer stability follows 1/tau very close. Based on these findings, we will discuss about the possible improvements of time and frequency transfer using the compact VLBI system. Additionally, the results of the fifth experiment scheduled in this February will be presented.