On the 2nd order fringe search in VLBI data processing

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1. Introduction

The length of a scan is several minutes at longest for a usual geodetic VLBI, and it is enough to search the rate of fringe-phase change with time for integrating correlated data over the scan. However, when observation for several 10 minutes or more is performed to detect a weak radio source, integration over the entire observation period is difficult due to the change of fringe phase caused by the second or more order phase change with time. We therefore developed new fringe search software that searches fringe-phase change up to the 2nd order component. As a result, the integration time without a coherence loss could extend to 30 minutes or more. We applied the new software to the VLBI observation of the Nozomi spacecraft when the intensity of its telemetry signal became extremely weak, and successfully detected the fringe unable to detect by the conventional search method.

2. 2nd-order fringe search

Correlation processing of the VLBI data usually passes through two steps. At first correlation is performed for a unit-processing period (PP) of a few seconds, then each PP data are further integrated to find fringes. When integration is made by a conventional method, only linear fringe-phase change with time (fringe rate) is compensated. Actual calculation and the search of wide range can be made effectively by using FFT. Considering from the stability of hydrogen maser standard and the observation period (several 100 sec at most), it is enough to search the fringe rate to obtain fringes. However, the necessity of making an orbital determination of Nozomi, a Japanese Mars explorer, by using VLBI under the condition of very weak signal intensity aroused. If the signal to noise ratio of each PP data is good enough to get fringe phase, the integration with compensating the phase change can be easily carried out. However, if signal intensity is very weak, we have to integrate the PP data with compensating phase change using a trial value given by a mathematical model. We developed new fringe search software that compensates fringe-phase change up to the 2nd order component to extend integration time. An algorithm used in the new fringe search is as follows. At first, fringe phase of each PP data is compensated by using the initial value of the 2nd order coefficient (t2dot). Followed by conventional fringe search is performed to find maximum correlation amplitude. The value of t2dot is then updated by adding a constant step value, and above search process is repeated till t2dot reaches the edge of search range. Finally correlation amplitudes at each trial t2dot values are compared, and the t2dot that gives the maximum correlation amplitude is determined. This search used to take huge time it was unrealistic for a routine work. Today if the search range is adequately set up, any PC can do the search without spending time so much. Assuming that the fringe phase rotation caused by t2dot is at most several times of rotations for 1000 sec at 8GHz, the search range of t2dot was set to -2.0E-15-+2.0E-15 (s/s^2).

3. Application to Nozomi VLBI observation

The Nozomi experienced the 1st earth swing-by in December, 2002, and will experience the 2nd earth swing-by in June, 2003 to cruise to Mars. The intensity of telemetry signals from the Nozomi became extremely weak after the 1st swing-by due to the geometrical relation between the attitude of Nozomi and the earth. We applied the new fringe search to the Nozomi VLBI observation made on January 23, 2003, and successfully detected the fringe which could not be detected by the conventional search method.

4. Summary

We developed new fringe search software that searches fringe-phase change up to the 2nd order component with respect to time. This new search method worked very well for Nozomi VLBI observation made under very weak signal condition. The new fringe search method can also contribute to observe very faint source for the radio source surveying.