High precision Interferometry Measurement on Normal TT&C Condition in China's Reentry Return Flight Test Mission

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ABSTRACT: China successfully carried out his first reentry return flight test mission, Oct. 24th to Nov. 1th, 2014, which was also called Chang E Five Test Mission (CE-5T1), for validating corresponding key technologies for China's lunar sample return mission. China's Deep Space Network (CDSN) in initial stage had been accomplished in 2013 for supporting China's deep space exploration mission, which consisted of two deep space stations, Jiamushi, Kashi, and two data processing centers in Beijing and Xi'an. In addition, the new China's Deep Space Interferometry System (CDSIS) based on CDSN was accomplished in December, 2013, consisted of two deep space stations and one interferometry data processing center in Beijing Aerospace Control Center (BACC), named Beijing Deep Space Interferometry Center (BDSIC).

Thus, CDSIS carried out CE-5T1 mission at first time, to provide high precision interferometry delay observations for CE-5T1 spacecraft orbit determination. However, the main task of these two deep space stations was for TT&C in CE-5T1 mission, it was mean that these two deep space stations should continuously track CE-5T1 spacecraft in their visible observation arc, thus, traditional Delta Differential One-way Range (△DOR) interferometry method, which needed to alternately observe spacecraft and quasars in short-term time intervals, could not be effectively applied in CE-5T1 mission. Since measurement system errors such as atmosphere error, ionosphere error, clock error, equipment error were needed to calibrate, thus, the interferometry system errors calibration was difficult in this case.

This paper proposed an integrated interfereometry data processing method, consisted of sparse data smoothing, differential correction calibration, high precision clock error modeling, environmental parameters delay compensation, to achieve high precision differential interferometry measurement system calibrations. This method used sparse quasars observation data, which is obtained by observing quasars before and after CE-5T1 spacecraft tracking, for interferometry system error calibration, to obtain high precision interferometry delay observations on normal TT&C condition.

CE-5T1 spacecraft was tracked by CDSIS in Earth-lunar transfer orbit, lunar swing-by orbit, lunar-Earth transfer orbit. TT&C signals and VLBI beacon signals of CE5T1 spacecraft downlink were utilized for interferometry signal processing to obtain delay observations in real-time. Meanwhile, the delay observations results after interferometry system errors calibration, were transmitted to CE-5T1 spacecraft orbit determination system in real-time or in quasi real-time for high precision orbit determination.

The delay observations, obtained by CDSIS, are utilized to jointly determinate CE-5T1 spacecraft orbit with range observations and velocity observations. Orbit determination residuals results shown that CDSIS interferometry precision was at the level of 1ns in CE-5T1 spacecraft's Earth-lunar transfer orbit, lunar swing-by orbit, lunar-Earth transfer orbit. For comparison, CDSIS delay residuals are compared with Chinese VLBI network delay residuals, which utilized the △DOR method in CE-5T1 interferometry mission. The compared results shown that, these two delay observation precisions were at the same level. In short， this paper's proposed integrated interfereometry data processing method was very effective, and strongly supported CE-5T1 orbit determination mission.