The effect of solution technique on the autonomous orbit determination accuracy of Lagrangian navigation satellite system

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Global navigation satellite system(GNSS) can deliver navigation information for spacecrafts which orbit on low-Earth orbits and medium Earth orbits. However, the GNSS cannot navigate the spacecraft on high-Earth orbit or deep space probes effectively. With the deep space exploration becoming a hot spot of aerospace, the demand for a deep space satellite navigation system is becoming increasingly prominent. Many researchers discussed the feasibility and performance of satellite navigation system on periodic orbits around the Earth-Moon libration points, as shown in figure 1. Autonomous orbit determination (AOD) is an important performance for the Lagrangian point satellite navigation system. With this ability, the Lagrangian point satellite navigation system can reduce the dependency on ground stations. AOD also can greatly reduce total system cost and assure mission continuity.

The AOD accuracy refers to the accuracy of the solution of the equations of motion. The solution technique is an approximation and will always introduce some error in the solution. To clarify this aspect, the terminology solution technique accuracy refers to the error introduced in the solution of equation motion by the solution technique should be discussed.

Two commonly used methods which are 4 order Runge-Kutta method(RK4) and 7(8) order Runge-Kutta-Fehlberg method(RKF78) are used to solve the motion equation of circular restricted three-body problem. We analysed the orbit prediction errors caused by the different truncation errors using RK4 and RKF78 for different libration orbits respectively. Since the characteristics of the Earth-Moon collinear libration points and triangular libration points are different, the prediction errors caused by different solution techniques about orbits around different libration points are illustrated. As shown in figure 2, the prediction error of L_1 libration satellte between RK4 and RKF78 in 30 days is about 1000m. The prediction error will be about 5×10^8 m in 60 days. Therefore it is necessary to analyse the effect of solution technique on the autonomous orbit determination accuracy of Lagrangian navigation satellite system. We also compare the AOD results with different solution techniques.

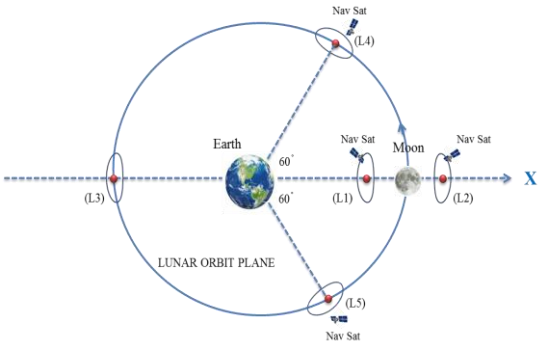

Fig1. 3D plot of the Lagrangian navigation satellite system

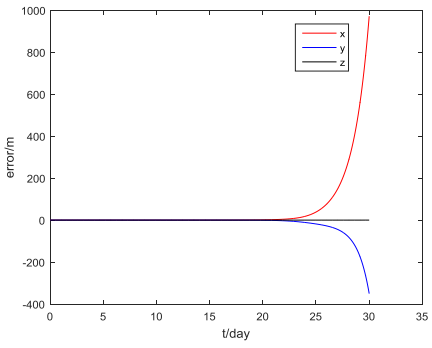

Fig. 2 The prediction error between RK4 and RKF78 in30days

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