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SPACECRAFT FORMATION FLYING CONFIGURATION DESIGN FOR SPACE-BASED GRAVITATIONAL WAVE OBSERVATORY

Abstract

There are a large number of gravitational wave sources in the universe. Gravitational wave observatory can provide key information for astronomy and cosmology that cannot be obtained by current means. Gravitational wave observatory include ground-based gravitational wave observatory and space-based gravitational wave observatory. Ground-based gravitational wave observatory is limited by ground noise interference and difficulty in configuration adjustment, so it can't observe low frequency gravitational waves and middle frequency gravitational waves. In order to overcome the shortcomings of ground-based gravitational wave observatory, space-based gravitational wave observatory based on spacecraft formation flight is favored. The basic principle of space-based gravitational wave observatory is to form a space-based equilateral triangle by three spacecraft, the distance variation between spacecraft caused by gravitational waves is measured by Michelson laser interferometry. This special measurement principle requires the formation configuration be a complete equilateral triangle. Different from constellation, the three spacecraft have the unique characteristics of large formation scale, high orbital stability and high formation control accuracy, but it is still relative motion of spacecraft in essence. However, it is affected by gravitational perturbation due to the non-spherical shape of the central body and the third celestial body, equilateral triangle configuration is easy to be destroyed, so how to get such strict equilateral triangle configuration? Many scholars have designed the regular triangle configuration, but most of them did not consider the perturbation or only designed by the first-order CW equation, which has a large error with the actual situation. Therefore, a configuration design method of equilateral triangle formation is proposed in this paper. Firstly, the space circular formation is constructed by using CW equation, and then equilateral triangle is constructed by uniform phase distribution. Due to the CW equation has only first-order accuracy, the state quantities of the three spacecraft are modified by differential correction to meet the optimization requirements. At the same time, J2 perturbation cannot be ignored in orbit

propagation. By considering the J2 invariance, the variation of arm length of the configuration was deduced by using the symplectic Runge-Kutta method that compared with the Runge-Kutta method on a time scale of 2 years. Through numerical simulation, it can be found that the variation of arm length of equilateral triangle does not exceed the error requirement for gravitational wave observatory, so configuration of equilateral triangle meet the requirements.