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THE STABILITY ANALYSIS OF ROTATIONAL TSS IN NEIGHBORHOOD OF COLLINEAR LIBRATION POINTS

Abstract

Tethered Satellite System (TSS) is a new kind of space applications which shows vast potential in practice. These applications include space scientific experiments, space transport, construction of large orbital architecture and so on. The classical definition of TSS means a system composed of two or more satellites connected by tethers. The sub-satellite can be deployed from base-satellite through a tether reeling mechanism. TSS is an area of intense research during the past three decades. Many scholars have done a great deal of researches about missions at Earth-Moon Lagrangian points. Dynamic environment without gravitational force makes Lagrangian points highly suitable places for space observation experiment and Gateway station. TSS is proved to be a good choice for missions at these points. Kim and Hall analyzed the formation of N-body TSS in SPECS project. They compared two formation types designed for the plan, Triangular formation and 'TetraStar' formation in their work. Colombo and Farquhar proposed the concept of stabilizing a TSS near a collinear libration point using tether length variation. Misra et al found the librational frequency of the tethers approximately and gave a similar result about stabilizing control of TSS as Farquhar. Additionally, Misra mentioned that a rotational TSS with constant tether length could stay in neighborhood of Lagrangian points for a relatively long time without control effort. But in his work he got the result only from numerical simulation while without any theoretical discussion. In this article, we try to give a theoretical explanation through deeply analysis of the rotational TSS consisted of two bodies near Earth-Moon collinear Lagrangian points. The equations of motion (EOM) for mass center and libration of tether are derived from Restricted Three Body Problem (RTBP) with second order terms. Then the simplified planar equations are solved analytically. The form of solutions indicates that both bounded motion and periodical motion are existed. Afterwards, an iterative method is applied to obtain the numerical periodical solution. The influences of the parameters such as angular velocity and mass ratio are analyzed. Finally, the long term motion of rotational TSS with initial value computed from numerical periodical solution is given via the numerical simulations.