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ORBITAL PROPULSION OF SPINNING TETHER VIA ANGULAR MOMENTUM TRANSFER

Abstract

During past decades, the spinning tethered systems were primarily discussed for specific space missions, for example the on-orbit capture and propellantless orbit transfer etc. such as the famous project Momentum-Exchange/Electrodynamic-Reboost (MXER) by NASA. As an elementary large-scale space structure, the spinning tethered binary system is intriguing for the dynamic behaviors and basic laws of motion control in gravity fields, which is essentially different from two-body system. The present work studies the dynamic behaviors of spinning tethered binary system, especially for that with the tether length variable. Considering the characteristics of coupled librational and orbital motions, a full orbit attitude model is developed, which is mainly concerned with the orbital motion of mass center. An averaging method is introduced to deal with the slow-fast system equations of the spinning tethered binary system then a definite equivalent model is derived. Thus, the general orbit motion is completely determined with an analytical method employed, including the orbit geometry, periodicity, conversations and moving region etc. Since the possibility of orbit control using tether deployment has been proved by previous studies, the general principles of orbital propulsion are still interesting and worth investigating. In this paper, special attention is paid to the transportation of angular momentum and mechanical energy between the orbit and tether spin, which governs the variation of mass center orbit. A perturbation method is applied to investigate the relationship between the orbit shape variation and the tether length change. The results show that the secular perturbation caused by the tether deploying and retrieving is the major factor that influences the orbit shape, and the orbit angular momentum and mechanical energy can be controlled independently. Numerical investigations under full model show the conclusions stated above are valid even without any approximations. The final part of this paper discusses some special applications of this technology in space missions.