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CHAOTIC MOTIONS OF TETHERED TUG-DEBRIS SYSTEM WITH FUEL RESIDUALS

Abstract

We consider the tethered tug-debris satellite system that is used for the active debris removal using low-thrust space tug. The post-burn phase of the active debris removal mission is investigated after the space tug fires up its thrusters. Although there have been several recent investigations in this area, many aspects of this problem remain unexplored. One of them is the chaotic behaviour of the system.

The space tug and debris connected by the tether move around the Earth in elliptical or circular orbit. The dynamic of the system is caused primarily by the tug's thrust and gravitational force and torque. The eccentricity of the orbit, longitudinal oscillations of the tether cause perturbations in the motion of the system. The effects of these perturbations are deeply investigated in published works. Yet another source of the perturbations is the motion of the fuel residuals in the tanks of the tug and/or debris. The effects of these perturbations on the motion of the tug-debris system are less investigated. Understanding the dynamical behaviour of this system is essential for the success of active debris removal mission.

In our work, we investigate chaotic motion of the system caused by the possible oscillations of the fuel residuals in the tanks of the tug and/or debris, eccentricity of the orbit, longitudinal oscillations of the tether and the thrust of the space tug. Stable and unstable stationary solutions are presented for the spatial motion of the system in a circular orbit, which depend on the value of the tug's thrust. It is shown that the unstable solutions give rise to the chaotic motion of the system in the presence of additional disturbances, including the motion of the fuel residuals in the tanks of the tug and/or debris. We consider the effects of the disturbances on the chaotic motion. Poincare sections and Lyapunov exponents are used to detect the chaotic processes in the considered dynamical system. The obtained results can be used for the design and analysis of future active debris removal missions.