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DYNAMICS AND CONTROL OF SPACE DEBRIS WITH FLEXIBLE APPENDAGES DURING
CONTACTLESS ION BEAM TRANSPORTATION

Abstract

The space debris removal problem has been actively discussed by the scientific community over the past decades. One of the promising directions for solving this issue is the creation of contactless transportation systems based on the use of an ion beam generated by an active spacecraft thruster. The main advantage of this technology is safety, since there is no need for direct mechanical contact between the active spacecraft and space debris. Previous studies have shown that the efficiency of transporting space debris by means of an ion beam is significantly affected by its angular motion, since the magnitude and direction of generated ion force depends on space debris shape and its orientation in the beam. To date, the ion transportation of space debris objects having the simplest shape (spheres and cylinders) has been studied in some detail. Meanwhile, many satellites have a more complex shape and, in addition, they are equipped with large solar panels that can perform elastic oscillations. The presence of these flexible appendages significantly complicates the dynamics of the mechanical system and requires additional research.

The aims of this work are to study an attitude motion of a passive space debris object with flexible appendages and to develop control law providing stabilization of the object oscillations in an equilibrium state. A mathematical model describing the planar motion of a passive space object with flexible appendages relative its center of mass under the influence of ion beam created by an active spacecraft is developed using Lagrange formalism. Analysis of the influence of the geometric characteristics of space debris and ion beam parameters on the space debris oscillations in a circular orbit was performed. Numerical simulation of the object motion under the action of an ion beam showed that the elastic oscillations of the panels have a weak effect on the angular motion of the space debris object. A control law for ion beam axis based on energy calculation, which ensures the transfer of the space debris object into the required mode of angular oscillations, was developed. The effectiveness of the law is confirmed by the results of numerical simulations. The results can be used in the development of new contactless transportation systems.