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OPTIMIZATION OF LOW-ENERGY TRAJECTORIES TO THE EARTH-MOON L2 HALO ORBIT WITH FINITE THRUST VIA PARAMETER CONTINUATION METHOD

Abstract

A novel method for optimization of low-energy trajectories of spacecraft (SC) with finite thrust according via parameter continuation method is presented. A restricted four-body problem is considered, which takes into account the gravitational potential of the Earth, the attraction of the Moon and the Sun, and high-precision ephemeris of the planets and the moon. Particular attention in the development of the method was paid to ensuring its computational stability during a prolonged stay of the spacecraft in the zone of weak stability near the boundary of the Earth's sphere of action. Low-energy flight to the Earth-Moon L2 halo orbit has great practical importance in the study of the Moon. The trajectory design problem in this paper can be streamlined as a trajectory design problem between a circular Earth orbit and discrete points on a stable manifold of the Earth-Moon L2 halo orbit. The problem of calculating the optimal trajectory of a low-thrust spacecraft can be reduced to just a two-point boundary value problem with several unknown parameters using the calculus of variations. The problem of calculation the two-impulse transfer trajectories is considered, the solution of which is necessary to serve as an initial approximation for the problem of optimizing the trajectories of spacecraft with a finite thrust. The main optimization criterion for this problem of space flight mechanics is the fuel consumption of the spacecraft. To solve this boundary value problem, the parameter continuation method is utilized, with the help of which the boundary value problem is formally reduced to the Cauchy problem. The two-impulse transfer trajectories are used as an initial approximation to the problem of calculating the optimal trajectory of a spacecraft with a limited thrust engine. To solve this optimization problem, a homotopy is constructed between the two-impulse trajectories and the trajectories of a spacecraft with a thrust-limited engine, and the parameter continuation method is used. A description of the mathematical model of the motion of the spacecraft, the formulation of the optimal control problem, the boundary value problem corresponding to it, and the method for solving it are given. On examples of optimization of typical flight, the efficiency and speed of the developed method are evaluated.