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NATURAL PERIODIC ORBIT-ATTITUDE BEHAVIORS FOR RIGID BODIES IN THREE-BODY PERIODIC ORBITS

Abstract

Trajectory design increasingly leverages multi-body dynamical structures, that are based on an understanding of various types of orbits in the Circular Restricted Three-Body Problem (CR3BP). Given the more complex dynamical environment, mission applications may also benefit from deeper insight into the attitude motion. The capability to employ the natural dynamics to avoid tumbling of captured asteroids, maintain space facilities in bounded oscillatory behavior, maneuver solar sails or point telescopes are a few examples of desirable applications. There is, therefore, a justified interest in investigating the attitude dynamics when it is coupled with the trajectories in the CR3BP.

In a highly sensitive dynamics, such as the orbit-attitude CR3BP, periodic solutions allow delineation of the fundamental dynamical structures. Periodic solutions are also a subset of motions that are bounded over an infinite time-span (assuming no perturbing factors), without the necessity to integrate over an infinite time interval. As is generally true in chaotic dynamics, it is difficult to determine a generic position or orientation of the vehicle that is likely to evolve into a bounded, regular motion.

In this investigation, Euler equations of motion and quaternion kinematics describe the rotational behavior of the spacecraft, whereas the translation of the center of mass is modeled by the CR3BP equations. Then, Floquet theory and Poincaré mappings are applied to identify solutions that are periodic in both the orbit and attitude states. In the Earth-Moon system, different representative scenarios are considered for axisymmetric vehicles with various inertia characteristics, that travel along L1/L2 Lyapunov as well as distant retrograde orbits. Using multiple shooting corrections schemes and continuation algorithms, several families of orbit-attitude periodic motions are constructed. A rich structure of possible periodic behaviors appears to pervade the solution space of the coupled problem. The stability analysis of the attitude dynamics for the available families is included. Among the computed solutions, marginally stable and slowly diverging rotational behavior exist and may offer interesting mission applications.