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PERIODIC ORBIT-ATTITUDE SOLUTIONS ALONG PLANAR ORBITS IN A PERTURBED CIRCULAR RESTRICTED THREE-BODY PROBLEM FOR THE EARTH-MOON SYSTEM

Abstract

The Earth-Moon system is nowadays attracting more and more interest as a well suited location for near and far future long term missions based on large structures. As a natural consequence, their design process has to go through a deep understanding of the orbital and attitude coupled motions which, although being significantly complex in a multi-attractors environment, may highlight interesting dynamical structures to be exploited for designing the vehicle passive guidance. Under the adoption of the Circular Restricted Three-Body Problem (CR3BP) model the understanding of either periodic or, at least, bounded behaviors for the rotational motion is still a young research field.

The paper presents a systematic approach to search and identify the aforementioned structures, beneficial for naturally coupled stable motions of large structures located in the Earth-Moon system: firstly planar orbit-attitude periodic solutions are obtained and classified for rigid bodies travelling along known CR3BP periodic trajectories, disturbed by the gravity gradient effects only. The torque exerted by Solar Radiation Pressure (SRP) is, next, introduced into the model. The performed analysis highlighted that even with SRP torque included, rotational periodic behaviors still exist for specific resonance ratios between the solar apparent motion and the spacecraft orbit periods. The assumption of the Sun apparent orbit to be coplanar with the Earth-Moon motion is adopted and its effects assessed with respect to the Sun ephemerides exploitation; the reference path is initially kept fixed, and deviations due to SRP are then analyzed leading to nearly-periodic solution structures. A sensitivity analysis incorporating SRP investigates the uncertainties on some spacecraft parameters (e.g. reflectance/absorbance coefficients, position of the center of pressure, irradiated area) and their effects on the orbit-attitude nominal motion.

As final step to refine the here presented model, the large structure flexibility has been inserted as perturbation, superimposed to a reference orbit-attitude rigid body motion: selected periodic solutions are assumed as reference and the modal and frequency analysis are performed, to detect excitation of the spacecraft structural modes and assess their effects with respect to the nominal rigid body solution. At the end, the presented model represents an effective tool to address and support the large structures in Earth-Moon system design, to preserve at the most a periodic nature of their coupled attitude-orbital dynamics. As a case study, the effectiveness of the proposed tool is discussed on a simplified extended space vehicle model.