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COUPLING ATTITUDE AND ORBITAL MOTION OF EXTENDED BODIES IN THE RESTRICTED CIRCULAR 3-BODY PROBLEM: A NOVEL STUDY ON EFFECTS AND POSSIBLE EXPLOITATIONS

Abstract

The current knowledge of the orbital dynamics in a multi-body system has been mainly built focusing on a point mass model to represent the actually extended space vehicle. Such an analysis already highlighted the great sensitivity this dynamics has to small perturbations to loose equilibrium configurations. Therefore, superimposing any sort of other dynamics may lead to strange but interesting behaviors exploitable for trajectory design and control. Besides natural perturbations the system is obviously affected, the dynamics provoked by the mass distribution within the vehicle actual extended configuration and its possible intrinsic flexibility are the further aspects to consider to step over. Therefore the presented study waives the assumption of a zero-dimensional space vehicle and looks at the effects of the mass distribution of the extended flying vehicle on both orbital and attitude motions in the framework of the Circular Restricted 3-Body Problem. To this end, the gravitational potential is expanded in Taylor series. The influence of higher order terms translate into the so called gravity-gradient. The effects of that perturbation in a multi-body gravitational environment has been only partially investigated with respect to the attitude dynamics, while still represent a significant novelty in the orbital motion. The two dynamics are naturally coupled when gravity gradient is incorporated and they both are addressed in this work. A variational formulation is here proposed to fully capture the perturbation effects. The selected osculating trajectories are planar periodic Liapunov orbits; a sensitivity analysis campaign according to the osculating parameters has been performed to deepen the knowledge about the effects of the refined dynamics model. The study focuses on different vehicles configurations closed - as far as possible - to real missions in libration points currently proposed by the space community. The aspect of flexibility, that always affects large structures, as well as natural perturbations, such as the solar pressure, are addressed too. Numerical results obtained show that the consequences of accounting extended configurations significantly affects the trajectory: even relatively small vehicles are perturbed from the reference path in a relatively limited time window, comparable with few orbital periods. The paper firstly presents the settled model to face the proposed problem; secondly discusses in deep the aforementioned dynamics behaviour in terms of orbital and attitude effects underlining the possible exploitation of the identified disturbances as effective tools to maneuver and control both the orbital and attitude time histories in the selected scenario.