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SWITCH POINTS FOR HIGHLY ECCENTRIC ORBITS: MODELLING THE OCCURRENCES OF SIGN CHANGES IN THE RATE OF CHANGE OF THE ECCENTRICITY

Abstract

The lunar and solar gravitational perturbations coupled with the J2 effect acting on Earth-orbiting satellites in critically-inclined highly eccentric orbits cause several modes of oscillation in the eccentricity of the orbit. The sign changes in the slope of the eccentricity variations are labelled "switch points" and their development is explored in this paper. Using spherical trigonometry, the switch points can be modelled in terms of the position and orbital elements of the perturbing third body (i.e., Moon or Sun) and the orbital elements of the satellite. Furthermore, the concept of switch point angles, used to identify when the switch points will occur, are defined and discussed. As a result, the fundamental nature of the interaction between the gravitational perturbations of the third body and the orbit of the satellite is expanded upon. The switch points are also used to analyze the different modes of oscillation that occur in the eccentricity variations, whose periods can vary from two weeks to several years, and as a result will cause significant variations in the perigee and apogee altitudes of the highly eccentric orbits. This study provides insight into the behaviour of the satellite's orbit under the lunar and solar perturbations in relation to the position of the Moon and Sun.