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REGULARIZED ANALYTICAL ORBIT THEORY WITH SOLAR RADIATION PRESSURE

Abstract

Solar Radiation Pressure (SRP) is one of the major perturbations acting on all the solar system objects including spacecraft and small bodies. The dynamics of SRP on an orbit depends on the shape, size and surface properties of the orbiting object; the shadow effects due to the central body and intensity of the SRP which is a function of the distance from source. For a high area to mass ratio space object, SRP will be dominant enough to cause major disturbance in the orbital motion. Accurate orbit predictability of space objects around Earth (high altitude and highly eccentric orbits) and in deep space is a necessity to carry out efficient mission analysis and operations.

To obtain accurate state vectors, while modelling complex forces such as third-body perturbations and SRP, the set of Newtonian dynamical equations of motion exhibits high nonlinearity leading to physical and computational limitations. They are also not preferred for developing analytical orbit theories. To overcome these difficulties, regularization can be utilized to produce a suitable formulation of the fundamental equations of motion. Kustaanheimo-Stiefel (KS) regularization results in linear differential equations of a harmonic oscillator which leads to KS regular elements equations of motion. KS regular elements based numerical and analytical propagators produce highly accurate solutions when complex perturbations are considered.

In this paper, a new singularity-free analytical solution for resident space objects using KS methodology with SRP is developed. Despite the increase in dimensionality of the system, there exists a symmetry in the set of KS equations which enables to solve only three out of ten equations thereby reducing the overhead time. Rest of the seven equations are solved by changing only initial conditions. Different shadow models including cylindrical and conical are implemented. The analytical solution is compared for performance and accuracy with KS numerical propagation, observed values of few space objects and previously developed methodologies.