ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (2) (4)

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INVARIANT MANIFOLD OF RELATIVE MOTION BETWEEN DISPLACED ORBITS

Abstract

For some solar sail astronomical observing missions that demand a reflector area of order 105m2 or even larger, it is impractical to compromise between technical requirement and industrial manufacture, and the problem can't be solved in a near future. Therefore it is necessary to introduce the concept of formation flying, which enables multiple sails to construct a larger virtual sensor and achieve greater resolution than a single sail.

There have been few reported efforts to understand the relative motion geometry and topology in the general case of two sails flying on displaced orbits. Recognizing this open question, we manage to establish a new set of orbital elements to define displaced orbit, based on which a closed-form solutions of relative motion may be obtained. Through coordinate transformation, the invariant manifold of relative motion between arbitrary two displaced orbits can be plotted, wherein the maximum, minimum, and mean distance of relative motion can be determined straightforwardly without solving nonlinear differential equations or resorting to linearization or series approximation. The methodology does also hold true for relative motion between elliptic displaced orbits since the eccentricity of displaced orbit is predetermined by the photonic solar pressure implemented on the sail based spacecraft. The relative motion exhibits periodicity for the commensurable case and quasi-periodicity for the non-commensurable case. Cognition of the maximum distance is crucial for communication system design, minimum distance is essential for collision avoidance, and mean distance is vital for power management.