ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (2) (7)

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SPATIAL APPROACHES TO MOONS FROM RESONANCE RELATIVE TO INVARIANT MANIFOLDS

Abstract

Trajectories approaching a moon, or the secondary in the circular restricted three-body problem, are analyzed here and placed within the context of the invariant manifolds of various unstable periodic orbits. Previous work examined the design of approaches to moons from resonance using the invariant manifolds of Lyapunov and resonant orbits in the planar problem. It was shown that the invariant manifolds of these unstable periodic orbits may also be used as guides for other trajectories to approach a moon. In this previous work, a preliminary analysis of these trajectories was initiated for the planar problem, and approach conditions were summarized.

An expansion on the analysis of the characteristics of these planar trajectories is undertaken here. The procedure uses a modified technique, originally based on the computation of collision orbits, which is used to integrate trajectories backward in time from various final states at the moon to a surface of section. The resonance at this surface of section may be computed, and the possible approach conditions that at each resonance may then be quantified. Large numbers of trajectories are computed in parallel using backward integrations, and various grids are evaluated to determine which ones capture the desired structures. This modified collision orbit technique focuses the study on the last portion of the approach and aids in the final goal of tying spatial approaches into a complete tour. The modified collision orbit method is applied here to the spatial problem to search for trajectories that meet desired mission constraints including inclination specifications. The analysis of spatial trajectories is particularly relevant for some current target orbits for various outer planet missions because they often require approaches to orbits that are at high inclinations. The characteristics of these trajectories are then analyzed within the context of the invariant manifolds of various unstable orbits, and mission design parameters of interest are quantified. The parameters of interest include the resonances that may be achieved, maneuver requirements, and the types of approach trajectories that are feasible for different energies and systems. Finally, the effects of using the modified collision orbit techniques in the ephemeris model are examined for selected cases, and particular cases with significant differences are studied in more detail. Overall, it is shown that the invariant manifolds of unstable periodic orbits may be used as a guide to understand and compute the various types of trajectories traveling toward moons in the spatial approach problem.