ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (2) (9)

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APPLICATION OF MONOTONIC BASIN HOPPING WITH DYNAMICAL SYSTEMS FOR CIS-LUNAR MISSIONS

Abstract

While Cis-lunar mission design can be improved by the implementation of dynamical systems into the overall design process, the choice of a single trajectory on such a determined manifold requires a method to select the trajectory profile that meets mission constraints. The selection of that trajectory currently relies on parameter mapping, or traditional differential correction, or optimization schemes. Thus targeting of a Cis-lunar mission such as the Lunar IceCube mission for capture into a lunar orbit via a multi-body trajectory can be challenging. In this investigation, we address the inclusion of a monotonic basin hopping (MBH) design strategy for achieving a Cis-lunar trajectory that satisfies the mission requirements. Development of the MBH procedure leverages analysis of the Earth-Moon dynamics via mapping techniques, orbital evolution predictions, and numerical simulations.

Injected into a direct lunar transfer as a payload onboard Exploration Mission-1 (EM-1) on the maiden flight of NASA's Space Launch System (SLS), Lunar IceCube will use a lunar gravity assisted multi-body transfer trajectory with an innovative RF Ion engine. Constraints on the outgoing translunar trajectory limit the types of feasible multibody transfers which re-encounter the Moon with the necessary ballistic capture energy and orbit orientation. For Lunar IceCube, key dynamical parameters must also be targeted to enable the captured trajectory to evolve into its final science orbit. The use of MBH will aid in the selection process of the most desirable transfer trajectories identified from dynamical systems to meet these design requirements.

An essential component of MBH is a controlled random search through the multi-dimensional space of possible solutions. Generally, the randomness has been generated by drawing random variables (RVs) from a uniform probability distribution. Here, we investigate generating the randomness by drawing the RVs from a Poincare mapping condition or other dynamical systems properties and trajectory constraints, chosen because of their characteristic application to this particular design problem. To perform this analysis, Purdue's Adaptive Trajectory Design (ATD) dynamical systems software and NASA GSFC's General Mission Analysis Tool (GMAT) high fidelity modeling environment are employed. The proposed MBH strategy for designing a transfer approach trajectory is demonstrated.