Paper ID: 68161
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

Author: Mr. David Lujan
University of Colorado Boulder, United States, dalu9892@colorado.edu

Prof. Daniel Scheeres
Colorado Center for Astrodynamics Research, University of Colorado, United States, scheeres@colorado.edu

DYNAMICS IN THE VICINITY OF THE STABLE HALO ORBITS

Abstract

The Earth-Moon L2 halo orbits are of growing interest among researchers due to NASA's upcoming Lunar Gateway that will be a proving grounds and outpost for missions to venture deeper into space. The Gateway will be staged in a nearly stable near rectilinear halo orbit. This has spurred research in a variety of areas to prepare for mission operations. Due to the location of the Gateway, it is important to understand the dynamics surrounding the halo orbit family. This work will be focused on the dynamical structures, namely the quasi-halo orbits and their invariant manifolds, in the vicinity of the stable halo orbits which are adjacent to the halo orbit that the Gateway will occupy.

A linear stability analysis of the halo orbits in this area shows the existence of two additional center manifolds, providing for two additional modes of oscillatory motion. This gives rise to stable 2- and 3-dimensional quasi-periodic tori (QPTs). However, the stability region only extends so far, and as such we aim to find the extents of the stable region where 3-dimensional QPTs exist. Outside of this region only unstable 2-dimensional QPTs exist. The behavior of their hyperbolic manifolds is of interest and will be studied. Both tasks are accomplished by computing the eigenvalues and eigenvectors of the stability matrix, like the monodromy matrix for a periodic orbit. A stable 2-dimensional QPT will have two pairs of identity eigenvalues and one pair lying on the unit circle in the complex plane. The instability is indicated when the complex pair bifurcate into an inverse pair on the real line indicating the existence of a hyperbolic manifold. The eigenvectors associated with this pair of eigenvalues dictate the directions to perturb the orbit to move onto the hyperbolic manifold.

The stable region of the halo orbits provides opportunities to study the use of tools for mission design. The work here will investigate which types of parametric constraints can be used to effectively explore the solution space of 3-dimensional QPTs and present findings about the family. Currently, we have computed families of 3-dimensional QPTs that have two of their three frequencies fixed, allowing only the remaining frequency to vary among the branch of family members. By utilizing other parametric constraints, such as the Jacobi Constant and amplitudes of each mode of oscillation, other family members can be computed and a method to move around the solution space can be constructed.