ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1) (1)

Author: Dr. Jeannette Heiligers
University of Strathclyde, United Kingdom

Mr. Sander Hiddink
Delft University of Technology (TU Delft), The Netherlands
Ir Ron Noomen
Delft University of Technology (TU Delft), The Netherlands
Prof. Colin R. McInnes
University of Strathclyde, United Kingdom

SOLAR SAIL PERIODIC ORBITS IN THE EARTH-MOON THREE-BODY PROBLEM

Abstract

Solar sail technology is rapidly gaining momentum after recent successes such as JAXA's IKAROS mission and NASA's NanoSail-D2 mission. Research in the field is flourishing and new solar sail initiatives are scheduled for the future such as NASA's Sunjammer mission. Solar sails exploit the radiation pressure generated by solar photons reflecting off a large, highly reflecting sail to produce a continuous thrust force. They are therefore not constrained by propellant mass, which gives them huge potential and enables a range of novel applications.

Many of these applications are found in the Sun-Earth three-body problem, including hovering above the ecliptic for high-latitude observations of the Earth and monitoring the Sun from a sub-L1 position for space weather forecasting. However, little research has been conducted to find applications of solar sails in the Earth-Moon three-body problem. The main reason for this is that, contrary to the Sun-Earth three-body problem, the Sun-direction is not fixed in the Earth-Moon problem, but rotates once per synodic lunar month. This makes the problem non-autonomous and makes periodic orbits harder to find.

Building on previous work in the literature that investigated individual periodic orbits in the Earth-Moon problem above the L2-point and below the lunar South Pole, this paper will search for entire families of periodic solar sail orbits around the collinear Lagrange points. These families of orbits are found under the assumption of a fixed attitude of the sail with respect to the changing Sun-direction. Furthermore, to guide the search, a continuation method is developed to depart from the natural Lagrange point orbits by gradually increasing the additional acceleration due to solar radiation pressure on the solar sail.

The resulting periodic orbits show an offset with respect to the natural Lagrange points similarly to solar sail periodic orbits in the Sun-Earth system. This offset can be exploited to improve a range of space applications, including Earth observation, space surveillance and Earth-Moon communications.