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SUN-EARTH LIBRATION POINTS TRANSFERS THROUGH EARTH-MOON GRAVITY ASSIST

Abstract

The use of multiple resonant Earth gravity assist is a well assessed technique, already employed in several space missions, to boost the spacecraft heliocentric velocity prior to performing swing-bys of other planets. A 1:1 resonant trajectory is often used, through an escape from the Earth's sphere of influence in radial direction, such that the Earth is re-encountered after about one year of ballistic cruise, and this encounter can be employed to increase the heliocentric energy through a gravitational assist manoeuvre. The gravity of the Moon, in combination with the Earth's one, might be employed to obtain an ulterior gain in heliocentric energy. In particular, several past and recent papers proposed combined Earth-Moon gravity assist trajectories, or multiple lunar resonances, in order to escape from the Earth-Moon system and connect to collinear Sun-Earth libration (SEL) points. The present paper offers a novel viewpoint on the problem, analysing transfers from Sun-Earth libration points towards other destinations, using the combined gravities of the Earth and the Moon. The unstable manifolds of the SEL points are initially employed to leave the corresponding regions; then, their intersections with the Moon's orbit are studied, providing the correct geometry to perform the described gravity assist manoeuvre. In particular, according to the phase angle at which the Moon is encountered, two families of trajectories are obtained: one is particularly suited for interior transfers, using the Moon to reduce the energy and being captured in the Earth-Moon system, and the other is suitable for escaping towards the inner solar system. The second family, nevertheless, does not allow for a direct escape, as the SEL manifold fixed geometry will result in a radial escape. Such feature can be beneficially exploited, at the expense of longer transfer time, to obtain a 1:1 resonance and perform a second Earth swingby. Eventually, this last swingby might be tuned to encounter the Moon prior or after the passage close to the Earth, to gain a boost in heliocentric velocity by properly deviating the geocentric velocity vector. The paper concludes with a case study, that showcases all the proposed transfer possibilities based on a possible real mission scenario, starting in a SEL collinear point and aiming for the main asteroid belt