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MAPPING OF JOVIAN MOONS VIA MULTIPLE FLYBYS

Abstract

Jupiter and its moons are one of the top candidates of exploration in future deep space missions. To achieve global coverage of the moons, a typical orbiter mission concept would require a large insertion maneuver which greatly reduces the mass reserved for scientific instruments. In this paper, we present an alternative way of achieving nearly global coverage without an insertion maneuver via multiple flybys.

Flybys at the moons should be carefully designed to maximize the scientific return. Following the work of Buffington et al., we study the relationship between the Jovian-centered orbits and the flyby groundtracks. We show that the possible locus of the flyby periapsis forms a great circle in the Jupiter-moon's frame. For a given pair of incoming and outgoing V_∞, we derive an analytical expression of the ΔV to achieve a small change in the flyby periapsis and groundtrack. From our Jovian tour designed for the GTOC6 (the 6th Global Trajectory Optimisation Competition) problem, we observe that it is easier to perturb the flyby periapsis along the great circle in the Jupiter-moon's frame, with ΔV less than 10 m/s, much less than the ΔV to perturb it outside the circle which could be up to 1 km/s.

We compare the efficiency of globally mapping a moon using flybys at the same moon (e.g. resonance transfers) in contrast to hopping among multiple moons (i.e. outgoing orbits determined by Lambert solutions). The transfer time is often fixed in resonance transfers while the time could be shorter in the 'moon-hopping' case. For example a 1:1 resonance at Callisto takes 16 days as compared to hopping from Callisto to Ganymede which can be as short as 4 days. This strategy is adopted in a few teams of GTOC6 to design a tour that maps the four Galilean moons in a limited mission time. As an example, we show a Jovian moon tour with over 140 hyperbolic flybys that requires only $\sim$80 m/s and almost globally maps ($> 90\%$) the four Galilean moons. Our methods are applicable to future mission scenarios (e.g. Jupiter Europa Orbiter) that demands observations and measurements on large areas of the moons of Jupiter, Saturn, and the Earth's Moon.

Ref.: [Buffington, B., Strange, N., and Campagnola, S., "Global Moon Coverage Via Hyperbolic Flybys," 23rd International Symposium on Space Flight Dynamics, Pasadena, CA, Oct. 29 - Nov. 2, 2012.]