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DESIGN OF SEQUENCE OF RESONANT FLYBYS AT EUROPA THROUGH THE FLYBY MAP

Abstract

Europa Clipper is a NASA scientific mission to study Europa and to investigate the presence of potential life, condition that places the icy-moon in the top priority list for NASA planetary exploration program. Europa Clipper's trajectory is a multi-moon orbiter mission accounting over 45 Europa, 5 Ganimede and 9 Callisto flybys answering to several design challenges: high resolution distributed observations of the surface of Europa under different luminosity conditions, high datalink and low radiation dose exposure, which constitutes the critical point for the design.

Europa Clipper exploits the gravitational interaction of the Galilean moons with the Jovian field but its design is still based on a patched conics modelling of such effects. Nevertheless, planetary moon systems, such as Jupiter one, exhibits strong perturbations that induce large errors in position and velocity on the two-body trajectory. Such discrepancies result in large delta-v and therefore in poor convergence when the orbit is refined in the full-model, accounting of the dynamics of the six-body problem represented by Jupiter and the Galilean moon system together with the perturbation induced by the Sun and Jupiter J2 effect.

The Flyby map is exploited to improve the design of Europa Clipper tour. The method numerically maps the non-linear effect of the flyby in the phase space of the Keplerian elements. Differently from the patched conics which model this effect with analytical formula, the Flyby map numerically propagates the Cartesian state in the three-body dynamics between two Poincaré sections and studies the variation of semi-major axis and inclination induced by different combination of osculating longitude and argument of the periapsis, modifying in turn the condition at the close approach.

More than two thirds of Clipper flybys about Europa consists in resonant flyby that foresees an increment and subsequent reduction of the inclination about Jupiter to achieve a specific distribution of the ground tracks over the icy-moon surface.

Differently from what patched conics theory suggests, the Flyby map allows to distinguish the different effect of prograde and retrograde flybys, indicates the existence of a natural sequence of resonant flybys that if followed lead to low delta-vs and offers initial conditions that are more prone to converge in the full-body dynamics. The paper describes in detail the generation of initial conditions for resonant flybys derived from the interpolated result of the Flyby map and their optimisation in the circular restricted three-body dynamics to obtain the desired sequence.