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THE DYNAMICS OF STATIONKEEPING STRATEGIES AROUND LIBRATION POINT ORBITS

Abstract

Over the past decade, there has been an increased interest in sending telescopes to Libration Points, especially Sun-Earth Libration 2 (SEL2). SEL2 is an ideal location for these telescopes because it allows for deep space observations, to help answer fundamental questions about our solar system and beyond, to take place in a thermally desirable environment. Examples of these telescopes include the James Webb Space Telescope (JWST) and the Wide Field Infrared Survey Telescope (WFIRST) that are planned to launch in 2021 and 2025 respectively. JWST's mission orbit is planned to be a large amplitude Halo, while WFIRST's mission orbit will be a slightly smaller quasi-Halo.

It is well known that periodic and quasi-periodic orbits around SEL2 are unstable. This means that stationkeeping strategies are required to cancel this instability and overcome the effect of other perturbations and uncertainties. It is also known that the linear dynamics around these orbits can be described with the Floquet modes: a set of periodic or quasi-periodic functions that provide a reference frame, centered at these orbits, where the dynamics can be simplified as a saddle x centre x centre motion. This reference frame has great potential for: (a) understanding and describing the motion around the Libration point orbits, and (b) finding minimum ΔV maneuvers to cancel the instability.

In the literature we find multiple methods to find the required maneuvers (called stationkeeping maneuvers) to maintain a mission orbit close using its natural periodic motion. In this paper we compare these different stationkeeping strategies from a dynamical point of view. We consider a set of reference periodic orbits in the Circular Restricted Three Body Problem (CRTBP), and apply the ΔV maneuvers provided by these stationkeeping strategies. The trajectories and the ΔV maneuvers are projected on the Floquet mode reference frame. By visualizing the ΔV maneuvers on the Floquet mode reference frame, the different stationkeeping methodologies can be compared in a true dynamical sense, helping the mission designer choose the stationkeeping method that is the most cost effective (in terms of total ΔV required over the mission lifetime) and is the most successful at meeting the mission requirements. Finally, we also discuss how different uncertainties, such as momentum unloads, navigation and maneuver execution errors, affect these control strategies and moreover, how to extend these study to a higher fidelity dynamical models.