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FUEL-EFFICIENT FORMATION FLYING OF AN OBSERVATORY AND EXTERNAL OCCULTER IN THE CIRCULAR RESTRICTED THREE-BODY PROBLEM

Abstract

The prolific discovery of habitable zone residing exoplanets via indirect detection methods have spurred many in the astrophysics and space technology community to call for the prioritization of funding for a direct exoplanet imaging space telescope, such as the NASA/JPL proposed HabEx mission. Though the state-of-the-art in optical technology suggests near-term feasibility, successful and efficient high-contrast imaging remains a problem. A promising solution is formation flying an external occulter in front of the space observatory to suppress host starlight and allow for imaging of the obscured exoplanet. However, recent analyses have demonstrated that for the required separation distance between the spacecraft, traditional angular slew maneuvers between target star systems in a design reference mission demand a significant amount of fuel, substantially restricting the potential science yield of a five year mission. This paper provides a first round proof-of-concept that elegant fuel efficient solutions can be uncovered that maximize exploitation of trajectories naturally existing within the nonlinear, multi-body problem phase space, as opposed to forced more direct or well understood paths created at the expense of fuel. The formation flying system is assumed to operate in the Sun-Earth L2 environment, thus for simplicity the phase space is currently limited to the Circular Restricted Three Body Problem assumptions. Results are generated via numerical search and optimization through a recently published exhaustive catalogue of families of periodic solutions and their initial conditions in this regime. These results are then compared to those generated via traditional optimal control methods. Future work will be dedicated to more rigorous investigating of the phase space described by the spacecrafts' relative dynamics through the lens of Dynamical Systems Theory.