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ASTEROID CAPTURE MISSIONS FOR UNATTAINABLE TARGETS USING EARTH RESONANT ENCOUNTERS

Abstract

Humanity's desire to explore the Solar System has been pushing forward space missions at a faster rate over the last decades. Our knowledge of most celestial bodies is still very lacking and consisting mainly on data gathered from distant observations. Nonetheless, the possibility of exploitation of Near Earth Asteroids (NEA) is being discussed, with the study of capture missions contemplating technology demonstrations and in-situ resource utilisation. These consist in making a spacecraft rendezvous with an asteroid and, using a deflection mechanism, moving it into an orbit in the vicinity of the Earth. Due to their relative proximity to this planet, NEA present themselves as good targets for this achievement. The asteroid's mass, which can be roughly estimated using data relative to its brightness in the sky, is a vital parameter for the trajectory design: in order to deflect the asteroid, the spacecraft must have enough fuel to move their combined mass. However, the propulsive capability of current systems may not be enough to retrieve some larger asteroids which would otherwise pose very interesting targets. In this way, this abstract presents a novel low-thrust trajectory that exploits the chaotic nature of our Solar System and its numerous gravitational perturbations as a way to capture heavier NEA. As a first guess for the optimal control problem, the proposed design includes a high-thrust trajectory starting with the application of an initial manoeuvre for a passage near the Earth, which we refer to as an Earth resonant encounter, and a posterior insertion into the target orbit on the next synodic period. This manoeuvre can be optimised in such a way that the resonant encounter with the Earth optimally modifies the asteroid's motion, so that heavier objects can be retrieved. The entire trajectory is first computed as an impulsive transfer in a Keplerian Map model, a low computational cost method that allows for a quick assessment of the asteroids which would benefit from the manoeuvre. Subsequently, the motion is refined using a higher-order method and, finally, the optimal control problem is solved to define the control sequence of the low-thrust transfer. Finally, several cases of asteroids whose mass would inhibit a direct capture mission were found; the ones whose capture is only possible when using the developed trajectory are presented. In this way, the asteroid pool for capture missions is expanded, making it so that a greater number of interesting bodies can be feasibly studied.