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Author: Mr. Wail Boumchita
University of Strathclyde, United Kingdom

Dr. Feng Jinglang
University of Strathclyde, United Kingdom

SEMI-ANALYTICAL ESTIMATION OF THE PROBABILITY OF CAPTURE INTO GROUND-TRACK RESONANCES OF DAWN AROUND VESTA.

Abstract

The DAWN mission demonstrated the feasibility of utilizing low-thrust propulsion for extended periods of time. The mission involves approaching asteroid Vesta from a high-altitude mission orbit (HAMO) to a low-altitude mission orbit (LAMO). As the spacecraft descends towards the asteroid, there is a likelihood that it might be captured by the 1:1 ground-track resonance. This occurs when the spacecraft encounters the same gravitational configuration at each revolution, which leads to significant changes in the orbital's eccentricity and inclination. With the increasing trend of using low-thrust propulsion in space exploration, it is essential to investigate the probability of capture into resonance for low-thrust spacecraft.

This research focuses on developing a semi-analytical methodology to estimate the probability of a low-thrust spacecraft's capture into 1:1 ground-track resonance of a low-thrust spacecraft around an asteroid in the context of the Dawn mission. Firstly, the two-degree-of-freedom Hamiltonian dynamical model of the 1:1 ground-track resonance around an asteroid is defined taking into account perturbations from the irregular gravitational field up to the second order and continuous low thrust that is constant in magnitude and always in the opposite direction of the spacecraft's velocity. Then, the effect of low-thrust on these degrees of freedom is characterized by analyzing their rate of change as a function of the thrust magnitude and the expressions are averaged over the mean anomaly. Finally, the probability of capture into resonance is estimated as a function of the energy balance, which is evaluated as it crosses the separatrix using a global adaptive quadrature method. The results are validated against numerical simulations using the equations of motion derived from the Hamiltonian of the dynamics. Beside, we we also study the probability of capture given different thrust magnitudes and different orbit geometries in terms of semimajor axis, eccentricity, and inclination.

Finally, the semi-analytical approach is applied to estimate the probability of capture into 2:3 ground-track resonance.

This research makes a significant contribution to the field of astrodynamics by systematically analysing the probability of low-thrust spacecraft's capture into resonances around asteroids, and also to efficient and robust mission design.