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NONLINEARLY STABLE EQUILIBRIA IN THE SUN-JUPITER-TROJAN-SPACECRAFT FOUR BODY PROBLEM.

Abstract

The Trojan asteroids have been highlighted as a main target for future discovery missions which will enable key questions about the formation of our Solar system to be answered. Programs like the Japanese Jupiter and Trojan Asteroids Exploration Programme are already testing technology demonstrators like the IKAROS hybrid spacecraft (propelled together by solar sail and low thrust) for interplanetary missions to Jupiter and the Trojans. In this paper a Hamiltonian formulation of the Sun Jupiter Trojan Spacecraft system, with the inclusion of low thrust, is presented in order to identify unique vantage orbits for viewing the Trojans. Setting the three primaries in the stable Lagrangian equilateral triangle configuration, eight natural (i.e. with zero thrust) equilibrium points are identified, four of which are close to the asteroid, two stable and two unstable. Artificial equilibria, which can be seen as low thrust perturbations of the natural ones, are then taken into account, with the aim of identifying their linearly stable subset. By the explicit determination of the generating function a symplectic change of coordinates is identified, which brings the Hamiltonian of the system into its normal form, a fundamental step for any application of KAM (Kolmogorov Arnold Moser) theory. Such theory, transforming a non-integrable system into a sum of perturbed integrable ones, enables the computation of a high order analytical approximation of the system dynamics, plus an estimation of the discrepancy from the initial model. As an application of basic KAM theory, a proof of the nonlinear stability for the low thrust generated equilibrium points under non resonant conditions is then found. Following this, a range of quasi-periodic orbits around the artificial equilibria, whose distance from the Asteroid itself is less than one fourth that of the stable natural equilibrium points, are identified, which enable a continuous synoptic view of the asteroid. Results show that, with the application of the classic normal form theorems it is possible to estimate the amplitude of the oscillations around an artificial equilibrium point, provided that the error on the initial state vector of the spacecraft stays within a certain domain.