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Author: Mr. Diogene Alessandro Dei Tos
Politecnico di Milano, Italy, diogenealessandro.deitos@polimi.it

Dr. Francesco Topputo
Politecnico di Milano, Italy, francesco.topputo@polimi.it

ANALYSIS OF BALLISTIC CAPTURE DYNAMICS WITH A SEMIANALYTICAL APPROACH

Abstract

Low-energy transfers in the n-body problem have gained central importance in space mission analysis and design. These orbits provide great advantages when compared to common keplerian solutions: fuel reduction, mission versatility, and wider launch windows. On the other hand, they feature an increased time of flight. Unfortunately, the global picture of the restricted n-body problem is yet to be thoroughly understood. The lack of invariant structures, such as periodic orbits and fixed points, translates into the frustrating need to explore the whole extent of a six-dimensional space, hoping to stumble upon the required solution. Slow direct methodologies, extensive grid searches, and use of brute computational power make the task rather demanding. The resulting solutions are not scalable and do not provide a deeper understanding of the complex chaotic dynamics at hand.

In this paper the phase space of the n-body problem in the neighbourhood of two primaries is analysed by means of a mixed general perturbation technique based on the Draper semianalytical satellite theory (DSST). The equations of motion are written in a planet-centred frame as perturbation of the two-body problem and a potential function is derived for the third-body terms. The disturbing potential is then written as a series of Legendre polynomials. This method produces approximate results that hold for some limited time interval depending on the actual third-body accelerations along the orbit. As the third-body accelerations approach those of a typical low-energy transfer, the semi-analytical method loses accuracy and tends to produce non reliable results. It is shown how the dynamical compliance is restored by splitting the trajectory in several legs and applying at each end a differential corrector. The semianalytical map that is obtained is then compared with the real solution of the full ephemeris problem in order to deepen the qualitative understanding of the n-body dynamics.