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Natural Formation Flying on Quasi-Halo Orbits in the Photogravitational Circular Restricted Three-Body Problem

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Abstract

Formation flying near a libration point is an effective method of the multi-point in-situ detection of deep-space environment and the high resolution observation of astronomy etc. This paper proposes a novel numerical searching method based on ergodic Poincaré mappings to seek natural formation flying on quasi-halo orbits in a photogravitational circular restricted three-body problem (PCR3BP). The reduced Hamiltonian system using the Lie series method gives a qualitative description of the phase space near the libration points. Then, an algorithm to return numerical solutions of invariant tori back to the synodic reference coordinate is presented. This research proposes a new type of Poincaré mapping from center manifolds of quasi-halo orbits onto the defined characteristic indexes in formation flying. Appropriate orbit groups, including two quasi-halo orbits, a halo orbit and a quasi-halo orbit, or multiple quasi-halo orbits, are all feasible for formation flying through numerically ergodic searching. Finally, the relative trajectory is considered unstable and a control scheme is required in practical formation flying.

Key Words: Formation flying; Quasi-halo orbits; Three-body problem; Libration point; Center manifold; Poincaré mapping

1. Introduction

Spacecraft formation flying has received increasing attention recently owing to its numerous benefits, such as a simpler design, faster build times, cheaper replacements causing higher redundancy, unprecedented high resolution, and the ability to view research targets from multiple angles or at multiple times. In addition, it is well known that the libration points of the circular restricted three-body problem (CR3BP) are quite promising locations for deep-space exploration missions. According to NASA's planned missions, the Terrestrial Planet Finder (TPF) and the Micro-Arcsecond X-ray Imaging Mission (MAXIM), formation flying near libration points is considered as one of the most important technologies in the future.

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