Configuration Design and Initialization Methods for Near-Earth Gravitational Wave Formations (Postprint)

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Abstract

Near-Earth miniaturized gravitational wave detection formations feature short development cycles and low costs, making them suitable for key technology verification in the early stages of gravitational wave projects and possessing significant engineering application value. Unlike deep-space environments, near-Earth gravitational wave formations are significantly affected by Earth's non-spherical gravitational perturbations, with inter-satellite distances prone to divergence that can lead to mission failure. Therefore, compared to typical deep-space gravitational wave detection formations, the design of naturally stable formation configurations in an uncontrolled state and their precise initialization constitute a completely new orbital design and control problem for near-Earth gravitational wave detection formations. This study employs orbital dynamics and relative motion dynamics in a two-body gravitational field as the foundation to conduct a preliminary design of an equilateral triangle formation configuration. Subsequently, aiming at long-term configuration stability, natural stable configurations under perturbation conditions are derived using perturbation analytical theory and intelligent optimization-based numerical search methods, thereby providing a stable configuration design scheme for near-Earth gravitational wave detection formations. Finally, to address the precise initialization problem of the detection configuration, a globally optimal differential correction strategy is investigated, achieving high-precision construction of near-Earth gravitational wave detection formations.

Full Text

Preamble

The provided text consists primarily of corrupted data, PDF encoding artifacts, and mathematical placeholders without coherent semantic content. No trans-

latable Chinese academic prose was detected in the source material.

Note: Figure translations are in progress. See original paper for figures.