IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

Author: Mr. CHAO REN
University of Chinese Academy of Sciences, China

Prof. Renyong Zhang
Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences, China
Ms. Zhuangcaiqing Zhou
University of Chinese Academy of Sciences, China

DRO TRANSFER DESIGN METHOD BASED ON THE STRETCHING DIRECTIONS IN CISLUNAR SPACE

Abstract

The launch of the first artificial satellite marked the beginning of human deep space exploration. The moon, Earth's only natural satellite, holds a vast amount of rare earth elements and other strategic resources, making it a potential base for future space exploration and development. Currently, in the second wave of lunar exploration fever, establishing an international lunar research station, manned lunar missions, and exploring water resources at the lunar south pole have become the primary lunar exploration goals for various spacefaring nations.

In pursuit of more scientific discoveries and a deeper understanding of the universe, humans are shifting their focus from near-Earth orbit to lunar orbit and even further into outer space. From the successful landing of the Apollo 11 spacecraft on the moon in 1969 to China's Chang'e-5 mission completing the country's first extraterrestrial sample return in 2020, human exploration of the moon has never ceased. To develop lunar resources and expand human influence on the moon, China plans to achieve manned lunar missions during the fourth phase of lunar exploration and subsequently establish a practical, multi-functional lunar base. Unlike traditional Keplerian motion, the moon's orbit is influenced by the gravitational forces of multiple celestial bodies, requiring more complex solutions such as multi-body dynamics to determine precise mission orbits. The Distant Retrograde Orbit (DRO) is a stable circular retrograde orbit proposed by NASA's Deep Space Gateway program in 2017, offering long-term stability and low orbital insertion energy, making it a potential staging point for future manned lunar missions. The challenge of stabilizing and efficiently finding the required mission orbits and conducting orbital transfers quickly is a top priority for scholars.

Addressing the transfer design issue of distant retrograde orbits (DRO) in the relatively stable Earth-Moon space where the theory of invariant manifolds is no longer applicable, this paper proposes a DRO orbit transfer design method based on the maximum stretching direction. Firstly, the characteristics of DRO orbits are analyzed using the stretching direction theory. Secondly, a method based on the maximum stretching direction is studied to achieve global phase synchronization and transfer design of DRO orbits. Lastly, a low-energy orbit transfer method among different DROs and NRHOs under gravitational forces is implemented to achieve the goal of deploying multiple satellites with one launch.