66th International Astronautical Congress 2015

MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Gravity and Fundamental Physics (1)

Author: Dr. An-Ming Wu
National Space Organization, Taiwan, China, amwu@nspo.narl.org.tw

Prof. Wei-Tou Ni
National Tsing Hua University, Taiwan, China, weitou@gmail.com

ASTROD-I ORBIT DESIGN AND MISSION SIMULATION

Abstract

ASTROD-I is a planned interplanetary space mission to test general relativity and to measure key solar system parameters. It is envisaged as the first in a series of ASTROD missions. ASTROD-I will consist of one spacecraft carrying a telescope, four lasers, two event timers, and a clock. Two-way two-wavelength laser pulse ranging will be used between the spacecraft in a solar orbit and deep space laser stations on Earth to achieve the mission goals. The spacecraft is required to reach the far side of Sun to measure the Shapiro effect (relativistic light retardation) to high precision. The orbit design is to find the initial state of the spacecraft to escape from Earth, to fly by Venus, and to enter a near half-year orbit.

DE431 solar ephemerides are utilized for the initial states of the solar system, and post-Newtonian formulation for the equations of motion of the celestial bodies and the spacecraft. An accurate 4th-order compact finite-difference method for the multi-body two-point boundary-value problem has been applied successfully to design the orbit. The results show that the spacecraft escapes from low-Earth orbit with delta-V of 1.421 km/s and propellant mass ratio of 0.364 assuming the specific impulse of 320 sec. As launched on Dec. 19, 2024, the spacecraft will fly by Venus after 140 days, and enter a near half-year orbit. During its three-year mission, the spacecraft will locate at the opposite side of Sun with respect to Earth three times. The apparent angles are within 0.30 deg, and the Shapiro time delays are larger than 0.1000 ms. The free flying nature of the spacecraft is also enable it to measure the physical properties of the solar system. Simulation using Kalman filter show that the errors can be reduced to several orders of magnitude for the masses of Sun, planets, Moon, and major asteroids.