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MERCURY SUN-SYNCHRONOUS ORBITER WITH A SOLAR SAIL

Abstract

The exploration of the Mercury investigates not only the nature of the planet itself but also the evolution of the Solar system. Orbits around the Mercury are influenced by the strong, periodic and time-varying gravity from the Sun. To deal with this problem, orbital dynamics and control are studied in this paper. The revolution velocities of the Earth and the Mercury are greatly different so that fuel economy is a big problem for missions which explore the Mercury from the Earth's launching sites. At present, numerous types of propulsion are available, in which solar sail is considered to be one of the most practical methods since it is capable of providing low thrust with infinite impulse. However, the orbit and attitude of a spacecraft propelled with solar sail are coupled strongly, and thus a big problem to be solved in the orbital designation and orbit control. Based on the predecessors' research, considering the illumination radiation pressure of the Sun, the research presented in this paper takes the gravitational perturbation of the Sun into consideration. Dynamics of 2-D and 3-D orbits are studied in the perturbed two-body model. Long-term changes and short-term variations of the orbital parameters are studied using averaged methods. The results show that Sun-synchronous orbiters with various orbit elements can be obtained by solar sail. As a side benefit, it is shown that the orbiters can remain stable in a long time. It is good for the orbiters to explore the whole surface of the Mercury or observe the Sun since the angle between the sunlight and the orientation of the solar sail remains constant so that it would not suffer from the great temperature changes between days and nights on the Sun-synchronous orbits. It is worth mentioning that the influence by the strong, periodic and time-varying gravity is not ignorable has been proved. Furthermore, the impacts to orbit of the spacecraft from the Sun's gravitational change with the variation of semi-major axis and eccentricity have been studied. Also, it has been found that the influence of the Sun's gravity aggravates with the increase of the semi-major axis so that more than ten percent of the solar acceleration is used to counteract the influence of the Sun's gravity. Give plenty of time, a spacecraft propelled with solar sail can move around the edge of the Mercury's influence sphere to carry out scientific research tasks.