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EXTENSION OF STABLE TERMINATOR ORBIT AROUND SMALL BODIES

Abstract

In the exploration mission of small bodies such as asteroids and comets, orbiting operation is very significant in terms of fuel saving and scientific observation of small bodies. Although the orbiting operation is very difficult because the gravity is small and the force field around a small body is strongly perturbed, there is a family of stable orbits which is called "Terminator Orbit (TO)" in such strongly perturbed environment where the solar radiation pressure (SRP) is dominant. While the TO is stable, it also has disadvantages. The TO's orbital plane must always face the sun and lack flexibility in orbit design. Moreover, since the orbital plane lies in night side, optical observation of the small body is extremely restricted.

This study extends the TO concept to a group of stable orbits which includes the TO and does not suffer from impact with surface or escaping. This extended TO is called "Quasi-Periodic Terminator Orbit (QPTO)" in this study. A whole solution including nonlinear region is surveyed systematically unlike some previous studies which analyzed the linearized space around a TO. This study verified that so-called TO is a part of the group of stable orbits around TO. At the same time QPTO improves the flexibility of the design of TO dramatically and provides several merits the TO does not have such as optical observation of the small body.

First, this study clarified that there is a boundary value of the initial condition determining whether the QPTO impacts with the small body or not by global search of the solution space with respect to the initial ascending node and the orbit size. The existence range of long-term stable QPTO was investigated. Subsequently, the Lagrange equations are solved by formulating the SRP force as a perturbation function and using averaging analysis to obtain the time transition of the eccentricity and the periapsis distance. Thus, we succeeded in analytically deriving the existence range of the long-term QPTO and verified that numerical and analytical solutions coincide well. As a result, the calculation time required for solving the existence range of the long-term stable QPTO can be greatly shortened, and it became possible to obtain the range when changing the strength of the small body's gravity and the SRP in accordance with various missions in a short time.

In this research, main results are shown using properties of Hayabusa2 and its target asteroid Ryugu as examples.