Family of Quasi-Stable Orbit around Asteroids in Strongly Perturbed Environment

Yusuke Oki,[1] Yuichi Tsuda[2*]

[1]*The University of Tokyo, Japan; [2]JAXA, Japan*

oki.yusuke@ac.jaxa.jp

Keyword : Solar Radiation Pressure, Augmented Elliptic Hill 3-Body Problem, Terminator Orbit

These days exploration of asteroid has been gathering attention around world because of its scientific and engineering importance. Spacecraft orbiting around the asteroid can conduct mapping the asteroid and measure gravity field of it more precisely than hovering above it. Moreover, orbiting can reduce fuel consumption compared to hovering. However, the dynamics around small body is so complicated due to the strong perturbation such as solar radiation pressure (SRP), tidal force and so on that it is difficult to orbit around the asteroid. Equations of motion around asteroids influenced perturbations are expressed by equations (1,2,3).

$$x''-2y'=\frac{1}{1+e\cos f}\left\{\left(3-\frac{\mu}{r^3}\right)x+a_{SRP}\right\} \tag{1}$$

$$y''-2x'=\frac{1}{1+e\cos f}\left(-\frac{\mu}{r^3}y\right) \tag{2}$$

$$z''+z=\frac{1}{1+e\cos f}\left(-\frac{\mu}{r^3}z\right) \tag{3}$$

These equations are defined in elliptic hill 3-body problem and *f, e* and a_{SRP} indicate true anomaly, eccentricity of asteroid and SRP force respectively. ' means *d/df*. There are stable orbit around asteroids even in this non‑keplerian system so called Terminator Orbits shown in Fig. 1 [1]. These orbits can exist only in very restricted position because their angular momentum vector must point toward or away from the Sun. Mapping of asteroid and measurement of gravitational field by S/C on the terminator orbit are restricted.

Therefore, this work extends the concept of terminator orbit. In this work trajectories around the asteroid without collision to the asteroid (Non-Reachable Orbit) are analysed in both analytical and numerical ways. At first, solution space of non-reachable orbit is examined numerically. And then, Oscillating orbital element is examined analytically using averaging analysis about SRP as perturbation function [2]. These two analytical and numerical results are compared in this work. This work contributes to extending the solution space of the useful orbit around small body in the view point of mapping asteroid and measurement of asteroid gravity. In this work the parameter of Hayabusa2 and its target asteroid Ryugu is used as an example.
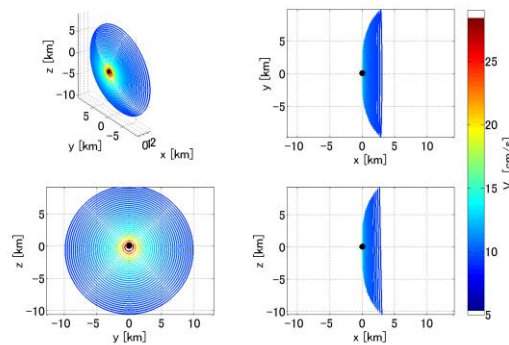

Fig. 1. Terminator Orbits around Ryugu

References

[1] D. J. Scheeres., Orbit Mechanics about Small Asteroids, 20th International Symposium on Space Flight Dynamics, Annapolis, September 2007.

[2] D. J. Scheeres., Satellite Dynamics about small bodies: Averaged Solar Radiation Pressure Effects1, Journal of the Astronautical Science, January 1999