Assessing the Hazard Posed by Ryugu Ejecta Dynamics on Haybusa2 spacecraft

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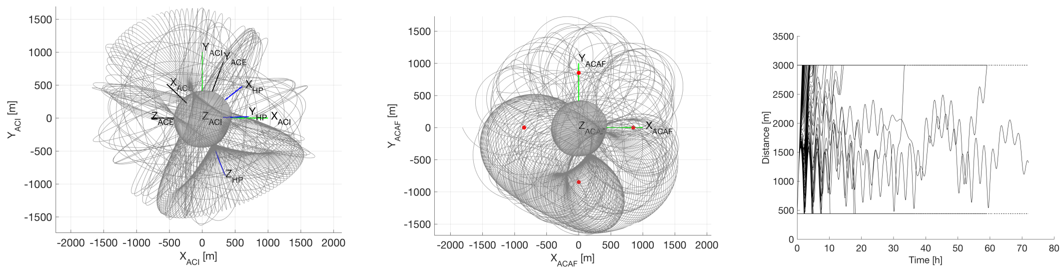
Hayabusa2 mission is the Japanese sample and return mission to Ryugu asteroid launched in 2014. It is the successor mission to JAXA's Hayabusa mission to Itokawa asteroid. Hayabusa2 spacecraft will encounter Ryugu in June 2018, followed by the asteroid touch-down mission phase in the first half of 2019. The challenge that Hayabusa2 spacecraft will encounter is the asteroid cratering mission phase. Hayabusa2 spacecraft is equipped with a small carry on impactor, and it is expected to create a crater of 2-3 m size in diameter to allow the sampling of substrate asteroid materials.
This paper investigates the hazard posed by the asteroid ejecta dynamics to Hayabusa2 spacecraft. Past studies concluded that the regions around Ryugu are expected to be cleared after two weeks from the impact event if size particles of 1 mm are considered. However, Ryugu asteroid is composed by regolith (highly porous) material with high likelihood of ejecta in 1 cm size. Natural impact phenomena on asteroids observed from Earth suggest that dust particles of 1 cm size in diameter can be captured for several months in orbit around the asteroid [1]. This condition is extremely dangerous for Hayabusa2 spacecraft as a collision with small particles can severely damage the spacecraft structure and compromise its functionality. The fate of the asteroid ejecta is here investigated through numerical modelling. A high fidelity dynamical model is used where the asteroids' gravity harmonics, its ephemeris, spin rotation and inclination, the solar radiation pressure perturbation and the effect of the Sun third-body perturbation are taken into account [2]. Equation (1) shows the dynamics for a perturbed two-body problem in the Asteroid-Centred Inertial frame:

$$\ddot{\boldsymbol{r}} = -\frac{\mu}{|\boldsymbol{r}|^3}\boldsymbol{r} + \boldsymbol{C}\,\frac{\partial \boldsymbol{B}}{\partial \boldsymbol{r}} - (1+\rho)P_0\,\frac{A}{m}\frac{(\boldsymbol{d}-\boldsymbol{r})}{|\boldsymbol{d}-\boldsymbol{r}|^3} - \mu_S\left(\frac{\boldsymbol{r}-\boldsymbol{d}}{|\boldsymbol{r}-\boldsymbol{d}|^3} - \frac{\boldsymbol{r}}{|\boldsymbol{r}|^3}\right). \qquad (1)$$

The dust cloud is initialised following analytical empirical laws obtained from experimental data [3]. Four sampling dust particles size of 0.1 mm, 1 mm, 1 cm, 0.1 m in diameter were selected as shown in [4] and numerical integrated. The ejecta trajectories are then compared as seen from the Asteroid-Centred Inertial (ACI), Fig. 1.a, the Asteroid-Cantered Asteroid-Fixed (ACAF), Fig. 2.b and the Hill frames to observe if the dust particles can naturally follow long-term evolution orbit around Ryugu for example in 1:1 resonant or terminator orbits, Fig. 1.c. Together with the numerical experiments, a preliminary analysis on the stability regions around Ryugu will be presented.



a. ACI Frame b. ACAF Frame. c. Distance from Ryugu

Fig. 1 Dust dynamics for particles of 1 cm size.

References

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