

Orbit of Hayabusa Spacecraft in its Cruising and Mission Phase

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Hayabusa (MUSES-C), the asteroid sample return mission of Japan, was launched on May 9, 2003, and it arrived at Asteroid (25143) Itokawa on September 12, 2005. It stayed around the asteroid more than three months and revealed strange features of this asteroid by taking a lot of data, which are quite interesting from the point of the planetary science. In this paper, we summarize the orbit of Hayabusa both in its cruising phase of more than two years and in its mission phase of about three months.

In the cruising phase, the principal items of orbit operation were the orbit determination under the ion engines (= continuous low thrust), the earth swingby, the solar conjunction, and the optical navigation. The orbit determination under the ion engines is a new item that we have never experienced in the previous missions of Japan. We tried to estimate the acceleration by the ion engines and we could do that at certain level. We are still investigating this item. As for the earth swingby and the solar conjunction, we had experience in the mission of NOZOMI and Hayabusa were able to go through these things successfully. Just after the solar conjunction, Hayabusa detected the image of the asteroid Itokawa, so we started the optical navigation. The optical navigation was successful and Hayabusa reached to the asteroid without any problem.

After arriving at the asteroid, Hayabusa was firstly moving around the point of about 20 km from the asteroid and then it went down around 7 km from the asteroid. In November 2005, Hayabusa tried several rehearsal approaches and executed touchdown twice. Hayabusa was located near the line connected the Earth and the asteroid except some occasions. In these proximate operations, the orbit of Hayabusa was determined by using the optical image data, the distance measured by LIDAR (Light Detection and Ranging), range, and Doppler data. At the same time, we estimated the solar radiation pressure, the gravity attraction from the asteroid, and some maneuver effects. Thus we were able to operate spacecraft around the asteroid, which is the smallest one that the man-made spacecraft have ever been to.

Now we have acquired the ability to reach such a small asteroid like Itokawa and to operate spacecraft around an object whose gravity is quite small. And also we have acquired the skill of descent to a small asteroid, touching down to it, and ascent from it. This skill is useful for future missions to small bodies in the solar system.