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Hayabusa2 Extended Mission : Hayabusa2#

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1. Introduction

The asteroid explorer Hayabusa2 successfully returned the samples of asteroid (162173) Ryugu to the Earth in December 2020[1],[2]. This is the second asteroid sample return mission in the world following Hayabusa, which brought the samples of asteroid (25143) Itokawa back to the Earth in 2010. It has passed more than two years since the capsule of Hayabusa2 was returned to the Earth. Up to now a lot of analyses of the Ryugu samples were carried out, and many interesting materials such as amino acids, liquid water, hydrated minerals, etc. were found.

The spacecraft itself was healthy without any serious problems and there was enough fuel, so we decided to continue the mission, and we call it Hayabusa2 Extended Mission, whose nickname is Hayabusa2#[3]. The character # (SHARP) is the acronym of "Small Hazardous Asteroid Reconnaissance Probe," which indicates that Hayabusa2# is related to the planetary defense deeply. Hayabusa2 will visit two asteroids, (98943) 2001 CC21 and 1998 KY26, both of which are near-Earth asteroids. In Fig.1, the orbits of these two asteroids as well as Ryugu are shown.

2. Mission scenario and purposes

After bringing back the samples of Ryugu in December 2020, Hayabusa2 spacecraft continues its voyage in the solar system. The first target is asteroid 2001 CC21. Hayabusa2 will flyby this asteroid in July 2026. Then Hayabusa2 will execute two Earth swing-bys in December 2027 and in June 2028, and it will rendezvous with the final target, asteroid 1998 KY26 in July 2031. Hayabusa2 will explore this asteroid for one year or so. Fig.2 shows this mission scenario schematically.

The total period of the extended mission is 11 years or longer. This is much longer than the nominal mission of 6 years. One of the purposes of the extended mission is to try long-term operation of spacecraft in space. We will investigate the time effects for the hardware of the spacecraft. We need to find ways to continue missions when certain equipment does not work properly. In

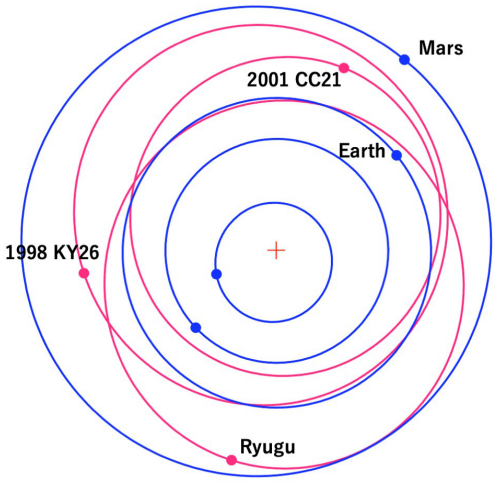

Fig.1 Orbits of asteroids that Hayabusa2 visited or will visit

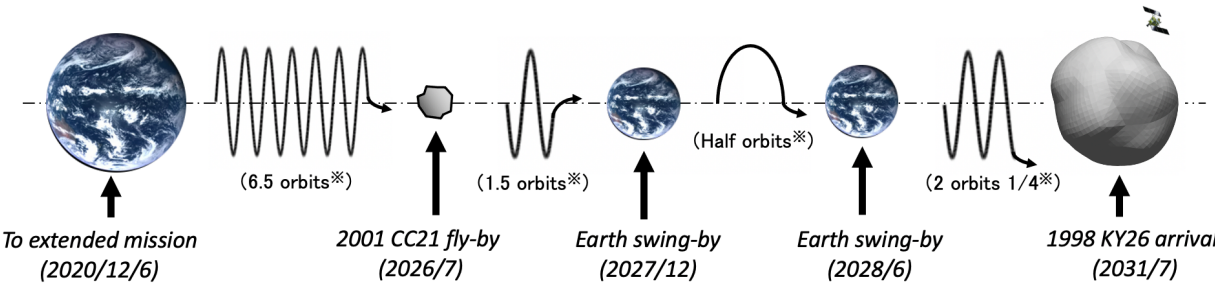

Fig.2 The mission scenario of Hayabusa2 extended mission (Hayabusa2#)
※ indicates the number of orbits around the Sun.

addition to this, we need to perform resource-saving operation to continue the long-term operation. These are engineering challenges.

As for science, we will study 2001 CC21 and 1998 KY26. 2001 CC21 was determined as L-type[4], and 1998 KY26 is very small (30m)[5] and its spin period is very short (about 11min). Spacecraft have never been to such asteroids so we will find many new facts from the point of the planetary science.

As I mentioned previous section, Hayabusa2 extended mission also has purposes for the planetary defense. We explain this in the following sections.

3. Operation for the flyby of 2001 CC21

In July 2026, Hayabusa2 will flyby 2001 CC21. The flyby velocity (relative velocity) is about 5 km/s, and the minimum distance to the asteroid should be less than 100 km. The closer the approach distance, the better the resolution of the observation. But the closer the distance, the greater the risk of colliding with the asteroid. Therefore, we need very precise navigation technique.

The navigation accuracy is very important for the planetary defense, because if we want to deflect an asteroid which is on a collision orbit to the Earth by impacting spacecraft to it like DART mission of NASA has done, we need navigation in very high accuracy. If we can acquire high-precision navigation technology through flyby operation of 2001 CC21, it will be useful for future planetary defense activities in Japan.

4. Rendezvous with 1998 KY26

In July 2031, Hayabusa2 will rendezvous with 1998 KY26. This asteroid is very small; the diameter is just about 30m. And it is spinning very fast; the spin period is about 11 min. The centrifugal force is larger than the gravity attraction at almost all the surface except for the polar regions. We have never been to such asteroid, so scientifically it is very interesting. In addition to this, we must take care of the Earth collision by such small objects, because the probability of collision of this size objects is about once in 100 years. Although it is small, but if it collides with the Earth, it will cause a big disaster. Therefore, if we know the physical characteristics of 1998 KY26, it is very useful for the study of avoidance of such type of asteroid collision with the Earth or minimization of the damage caused by the collision.

5. Summary

Hayabusa2 extended mission Hayabusa2# is now underway. The target asteroids are near-Earth asteroids, 2001 CC21 and 1998 KY26. Both asteroids are interesting from the point of planetary science. Also Hayabusa2 extended mission has many engineering purposes related to the long-term spacecraft operation. In addition to these, Hayabusa2 extended mission contribute to the planetary defense in spacecraft navigation technique and getting information of the types of asteroids that have large probability of colliding with the Earth.

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