Mass estimation of Asteroid Itokawa

Makoto Yoshikawa[1]; Takashi Kominato[2]; Masatoshi Matsuoka[2]; Ken'ichi Shirakawa[2]; Hitoshi Ikeda[3]; Takafumi Ohnishi[4]; Shinsuke Abe[5]; Tadashi Mukai[6]; Hajime Yano[7]; Daniel Scheeres[8]; Robert Gaskell[9]; Jun Saito[10]; Takashi Kubota[11]; Tatsuaki Hashimoto[11]; Akira Fujiwara[10]; Junichiro Kawaguchi[11]

[1] ISAS/JAXA; [2] none; [3] Aeronautics and Astronautics, Kyushu Univ.; [4] Fujitsu Ltd.; [5] Kobe University; [6] Earth and Planetary System Sciences, Kobe Univ; [7] Dept. of Planetary Sci., JAXA/ISAS; [8] The University of Michigan; [9] JPL; [10] ISAS; [11] JAXA/ISAS

Hayabusa spacecraft arrived at its destination, Asteroid Itokawa, in September 2005. After observing the asteroid in detail, it tried touching down on the surface of the asteroid. Hayabusa was moving near Itokawa for about three months for these missions, so we were able to estimate the mass of Itokawa by analyzing its motion. In this paper, we summarize the results of mass determination by several different methods in different orbital phase.

Hayabusa arrived at Itokawa on September 12, and at first it stayed around the position of 20 km from Itokawa (We call this position as 'gate position'). After that, Hayabusa moved a little closer to the asteroid, and it reached to the place called 'home position', the distance from Itokawa is about 7 km. Using the range and Doppler data from Sept. 12 to Oct. 2, the mass of Itokawa was estimated as 3.51 x 10^10 kg. Since the effect of the solar radiation pressure is much larger than that of the gravitational attraction from Itokawa, the error of this estimation is about 15 %.

We expected that we could get more precise value of the mass of Itokawa when Hayabusa approached much closer to it. However one of the two reaction wheels, which were working at that time, had a trouble, and after Oct. 3 the attitude control was done by the chemical thrusters. The chemical thrusters generated small orbital acceleration, so it became difficult to carry out the precise mass determination of Itokawa. Therefore, we intentionally stopped the attitude maneuvers on Oct. 21-22, when distance from Itokawa is about 3 km. On this pass we tried to determine the mass of Itokawa, and we got the value of 3.43 x 10^10 kg with the error of 5%. Up to this analysis, we assume a point mass model for Itokawa.

In November, Hayabusa closely approached Itokawa several times for the approach rehearsals and the actual touchdowns. For the approach on Nov. 12, the orbit of Hayabusa was determined accurately by using LIDAR (Light Detection and Ranging) and the optical images. At the same time, the mass of Itokawa was estimated as 3.54 x 10^10 kg with the error of 6%. At this time many orbital maneuvers were carried out, so the accelerations by such maneuvers were also estimated. The distance from Itokawa was 800 m to 100 m, so the polyhedron model is used to calculate the gravity potential of Itokawa.

On Nov. 19, the first touchdown was executed. At this time Hayabusa was put in the state of the free fall from the height of about 20 m. We were able to obtain the data of LRF (Laser Range Finder), and we are trying to determine the local gravity by using the distance data from LRF.

As the summary, we can say that the mass of Itokawa is most probably around 3.5 x 10^10 kg. The volume of Itokawa determined by other groups is 1.74 - 1.84 x 10^7 m^3, so the bulk density of Itokawa is about 1.9 - 2.0 g/cm^3.