

# **The operation and scientific data of MINERVA rover in Hayabusa mission**

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## **1 Introduction**

The asteroid explorer “Hayabusa” operated by Institute of Space and Astronautical Science (ISAS), JAXA made a rendezvous with the target asteroid “Itokawa” in September 2005 after more than two years’ interplanetary cruise since the launch in 2003. The spacecraft precisely observed the target from the vicinity of the asteroid for two months and then tried to land on the surface in order to get some fragments, which will be brought back to the Earth.

The authors installed a experimental small rover named “MINERVA” into the spacecraft. It was supposed to make a surface exploration after having been deployed onto the surface. MINERVA is the smallest spacecraft with a weight of 591[g] and a dimension of about 10[cm] in size. In this small body, it is equipped with a moving ability over the micro-gravity environment on the asteroid and a few scientific instruments (cameras and thermometers) to characterize the surface.

MINERVA was deployed in November 2005, but it could not reach at the asteroid because the deployment was not done at the good timing. Thus it became a artificial solar satellite and the surface exploration was not conducted. It survived at least for 18 hours after the deployment while the obtained data were transmitted to the Earth via the mother spacecraft.

This paper describes the operation and the possible science from the obtained data by MINERVA.

## **2 Deployment**

MINERVA was deployed in November 12, 2005 by sending a command from the Earth when the rehearsal operation of the touchdown was in the climax with the spacecraft very near to the asteroid.

Unfortunately the Hayabusa spacecraft was getting away with a relative speed of

15[cm/s] from the asteroid when the command was reached at the spacecraft. Thus the deployed small probe was not trapped gravitationally into the asteroid, but became an artificial planet orbiting around the Sun.

### **3 Operation**

MINERVA has an autonomous ability to explore the surface. Because there is a round-trip time delay of more than 30 minutes between the asteroid and the Earth, teleoperating the rover is not practical.

The communication link between the rover and the spacecraft was continuously established after the deployment. The Hayabusa spacecraft received the data from MINERVA which were obtained autonomously. According to the transmitted data, MINERVA worked very normally after the deployment.

After 18 hours passed since the deployment, the communication link was lost and has never recovered. The estimated reason of the disconnection is that MINERVA went out of the scope which the antenna mounted on the Hayabusa spacecraft covers. There was no sign of malfunction by the last telemetry from MINERVA.

### **4 Acquired data and Science**

MINERVA captured the image of the spacecraft Hayabusa immediately after the deployment. That is the first picture which photographed the spacecraft in the deep space.

The house-keeping data of the voltage of the battery, the temperatures of the devices, and the incoming light by the photo diodes were periodically measured and transmitted to the Hayabusa spacecraft.

The temperature history was influenced by the radiation from the asteroid because it was different from the one when MINERVA had been attached to the spacecraft during the interplanetary cruise.

After the rover was gone, the thermometers onboard the Hayabusa spacecraft to monitor the temperature of the rover were directly revealed. They are thermally separated from the spacecraft and were very sensitive to the radiation from the asteroid when the spacecraft descended to the surface.