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Development of Hayabusa-2 Deployable Camera (DCAM3) for observation of impact simulation on asteroid

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Abstract

A miniaturized optical camera unit (DCAM3) is being developed for observations of an artificial impact made by Small Carry-On Impactor (SCI) on asteroid 1999JU3 in the Hayabusa-2 mission. DCAM3 takes images of spreading ejecta motion on the asteroid, which provides information of surface physical properties and ejecta behavior under microgravity. The flight model of DCAM3 is under development and operation tests. The science and instrumental concepts and development status are reported.

1. Introduction

Collisions between primitive planetary bodies are one of the most important physical processes in the planetary accretion from planetesimals to planets. Asteroids are small primitive bodies on the way to the larger bodies or the fragment bodies such as rubble piles of the evolved bodies, so that the asteroids are possibly be recognized as fossil bodies showing the accretion process in the solar nebula. Impact studies on the asteroid, such as the impact scaling rules related to the cratering and the disruption, are important to reveal the actual manner of planetary accretions in early stage of the evolution.

In the future Japanese Hayabusa-2 mission, Small Carry-on Impactor (SCI), which is a small detachable launcher of an artificial projectile, will make an impact simulation on asteroid 1999JU3 [1] (Figure 1). A copper-disk projectile is deformed by explosive in the SCI and forms a semi-spherical shell, and is accelerated to approx. 2 km/s [2]. The tiny asteroid 1999JU3 is a good analogue of planetesimals and suitable to study the effect of micro-gravity on the impact process and elucidate the mechanical properties of planetesimals.

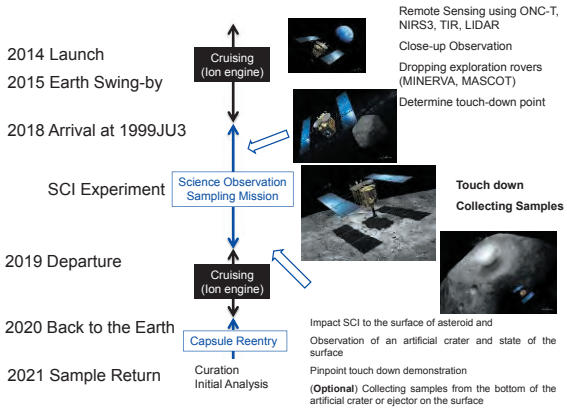

Figure 1: Mission schedule of Hayabusa-2. DCAM3 will observe an impact in the SCI Experiment.

2. Concept of DCAM3

The Deployable Camera (DCAM3) is a miniaturized detachable camera inherited from DCAM1,2 in the Japanese IKAROS mission [3]. The DCAM3 is currently under development for observations of the SCI impact. A separable instrument is necessary to obtain close up views of the impact, because the mother ship will be hiding in a safe region far from the impact point to avoid a risk that the mother ship encounters high-speed ejecta from the asteroid during the impact operation.

The impact observation part in the DCAM3 system consist of a separable small camera cylinder, its detachment instrument, and receiving antennas on the mother ship (Figure 2). After separation in the SCI impact operation, DCAM3 starts its observation at visible wavelength and sends image data on one-way communication to the mother ship. Design of DCAM3 is similar to IKAROS DCAM1,2 (Figure 3), but has an additional high-resolution camera in the body.

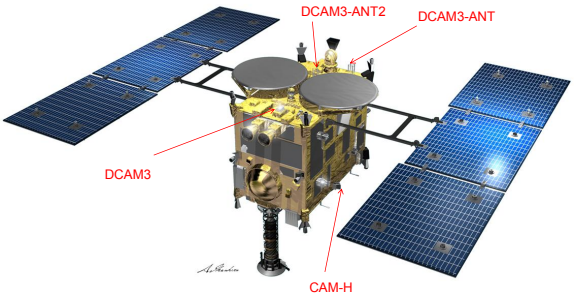

Figure 2: Components of DCAM3 system on the Hayabusa-2 mother ship.

Figure 3: A photograph of IKAROS DCAM1,2. Body diameter is approx. 60 mm.

3. Scientific Observation

The scientific observations are performed by "DCAM3-D" that is a wide-angle high-resolution camera and its fast digital transmission component in the DCAM3 body. Scientific objectives of this camera are summarized as (1) clarifying the sub-surface structure, and (2) constructing the impact-scaling rule applicable to the surface of asteroid 1999JU3. Observation objects of the camera are ejecta and a subsequent crater of the SCI impact, and a relative position of the SCI to the asteroid when it is launched. DCAM3-D can determine the size and the angle of the ejecta curtain, and the speed of the ejecta spreading or fragment spattering, which are the key information for the above objectives. In addition, low-speed ejecta (dust) spreading will possibly be observed around the DCAM3 in a few hours after the impact.

The DCAM3-D CMOS sensor produces 2000 x 2000 pixels 8 bit monochromatic images with a 74 x 74 degrees wide-angle optics. It takes 1 frame/sec sequential images at maximum. Figure 4 shows a virtual image of spreading ejecta on asteroid 1999JU3 taken by the DCAM3-D in an ideal position. The optical camera has enough-high space resolution and bright resolution for its sciences. DCAM3 continues to produce data for a few hours until batteries runs out or the DCAM3 falls and crashes on the asteroid. The digital communication device can send the image data to the mother ship with 4 Mbps at maximum. Instruments in the mother ship store all data taken by the deployed camera. Total size of image data is estimated to be approximately 5 Gbits after compression.

So far, we conducted the conceptual examinations to specify the required specification of the camera and a communication device. Engineering models for all components of DCAM3 were manufactured, and verification tests were conducted with them. The flight models are currently in tests for the observation and communication performances.

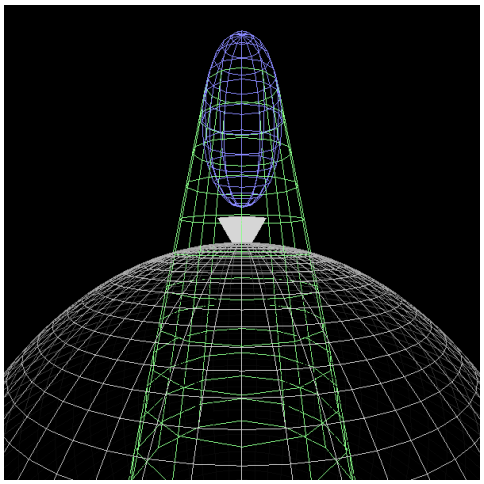

Figure 4: A virtual image of asteroid 1999JU3 and ejecta cone taken by DCAM3-D camera. The blue oval sphere shows a potential region in which SCI exists. The green cone shows a possible trajectry of the projectile.

References

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