SMALL CARRY-ON IMPACTOR (SCI): ITS SCIENTIFIC PURPOSE, OPERATION, AND OBSERVATION PLAN IN HAYABYSA-2 MISSION. M. Arakawa¹, T. Saiki², K. Wada³, T. Kadono⁴, Y. Takagi⁵, K. Shirai², C. Okamoto², H. Yano², M. Hayakawa², S. Nakazawa², N. Hirata⁶, M. Kobayashi³, P. Michel⁷, M. Jutzi⁸, H. Imamura², K. Ogawa², Y. Iijima², R. Honda⁹, K. Ishibashi³, H. Hayakawa², H. Sawada², ¹Kobe Univ. (masahiko.arakawa@penguin.kobe-u.ac.jp), ²JAXA, ³PERC/Chitech, ⁴Univ. of Occupational and Environmental Health, ⁵Aichi Toho Univ., ⁶Univ. of Aizu, ⁷Observatoire de la Cote d'Azur, ⁸Univ. of Bern, ⁹Kochi Univ.

Introduction: Collisions among planetary bodies are one of the most important physical processes in the planetary accretion process 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 we can recognize asteroids as fossil bodies showing the accretion process in the solar nebula. Therefore, asteroids are studied to reconstruct the planetary growth process, and the impact scaling rules related to the cratering and the disruption are necessary for this reconstruction. The 1999JU3 is a tiny asteroid suitable for the analogue of planetesimals and it will be studied to clarify the effect of micro-gravity on the impact process and elucidate the mechanical properties of planetesimals. The surface of asteroids such as 1999JU3 is continuously suffered by space weathering and thermally altered by solar radiation. Moreover, continual impacts of small bodies renew the surface through seismic shaking and regolith formation or removal. This active surface processes

should be studied to clarify the present physical environment on the asteroid surface related to the evolution of these tiny asteroids.

Small Carry-on Impactor (SCI) is one of the instruments carried on Hayabusa-2 space craft and it will be used for an active exploration on the surface of asteroid 1999JU3. The SCI consists of a disk impactor made of copper with a diameter of 30 cm (Fig. 1). This disk will be deformed by an explosion to form a semi-spherical shell and be accelerated to a velocity ~ 2km/s for the collision onto the asteroid surface (Fig. 2).

The SCI impact enables us to conduct sampling from the interior of the asteroid, so the sample will be recovered from the floor of the artificial crater or the surrounding area covered with the ejecta from the SCI artificial crater. The artificial crater will produce a new fresh surface that is expected not to be significantly suffered from space weathering. In addition to sampling, remote sensing from the space craft will be able to refer this fresh surface in order to recognize the de-

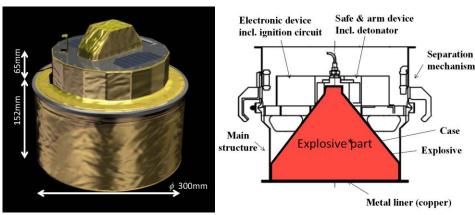
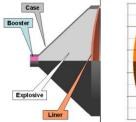


Fig.1: Appearance (left) and cross-section (right) of SCI.



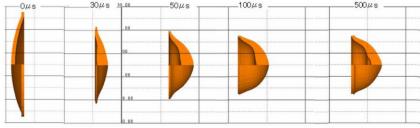


Fig. 2: Time evolution of the copper liner after explosion of SCI.

gree of space weathering on other surfaces and also observe the subsurface structure on the crater wall.

Scientific Purposes of SCI: As described above, the first purpose of the SCI impact is to clarify the subsurface structure. The asteroid surface is continually shaken by high-velocity impacts and changed by the space weathering and the thermal alteration owing to the solar radiation. We are interested in this present dynamics working on the asteroid surface, thus the sample should be recovered from the ejecta deposit in order to elucidate the dynamics. The depth information of the recovered sample is very critical to reconstruct the sub-surface structure. We should use the crater scaling rule, especially for the ejecta scaling, to estimate the original depth of the recovered sample. Therefore, the crater formation mechanism should be studied on 1999JU3 to obtain the impact scaling rule applicable to the surface on the asteroid.

However, we have no reliable information of the surface properties of 1999JU3 to apply the impact scaling rule for the SCI impact crater. Thus, the second purpose of the SCI is to clarify the sub-surface physical properties of the 1999JU3 and to construct the impact scaling rule applicable to the surface of this tiny asteroid. Moreover, the tiny bodies like 1999JU3 and Itokawa have a large advantage to investigate the effect of gravity on the crater formation process because on the earth it is quite difficult to study the gravity effect on the crater formation, so the SCI impact could be used to refine the crater scaling rule especially related to the gravity.

Operation: Fig. 3 shows the simple overview of the operation plan of SCI. SCI is separated from Hayabusa-2 at an altitude of several hundred m (nominally 500 m) from the surface of 1999JU3. Having no thrusters, SCI floats and descends toward the asteroid due to its gravity. After waiting for 1 minute or so, Hayabusa-2 itself starts to escape from the separation point, going into the shade region of the asteroid, in order to avoid

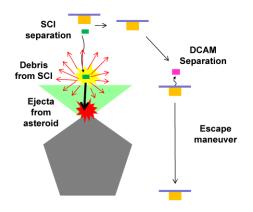


Fig. 3: Overview of SCI operation plan.

debris from SCI explosion and ejecta from the newly formed impact crater. On the way to escape, Hayabusa-2 separates a deployable camera (DCAM3) that aims to observe the floating and explosion of SCI and the ejecta distribution from the crater. After several tens of minutes (nominally 40 min) from separation, SCI is exploded with an onboard timer and then the copper liner impacts onto the asteroid. The liner is expected to impact within a circle region of 200 m radius. Hayabusa-2 will keep escaping over 200 km away from the asteroid. Then, Hayabusa-2 will be back to the asteroid, spending more than 2 weeks for its safety from ejecta floating around the asteroid. After coming back, Hayabusa-2 will find, observe, and touch-down to or around the crater.

Observation Plan: First, the SCI impact will be observed with DCAM3. Recording images of the ejecta curtain or the impact fragments by means of DCAM3 will make it possible to investigate the sub-surface physical properties and the ejection process in impact cratering. DCAM3 is a palm-sized deployable camera device. It has two camera components inside: DCAM3-A and DCAM3-D. DCAM3-D is planned for the above scientific observation and its spec is listed on Table 1. Second, the artificial crater will be explored by the remote sensing equipments onboard Hayabusa-2, i.e., Optical Navigation Camera (ONC), Thermal InfraRed Imager (TIR), and Near InfraRed Spectrometer (NIRS3) to obtain the basic parameters of the impact crater and the various kinds of information of the fresh surface and the subsurface structure. Such information will be used to determine the physical properties of the subsurface material and to refine the crater scaling rule for the ejecta velocity distribution and the crater diameter. The cooperation between the laboratory experiments and the numerical simulations is very important to utilize the obtained results and to conduct the realistic extrapolation of the scaling rule toward the large scale.

Table 1: Main specifications of DCAM3-D scientific camera

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Size of lens tube	ф30 x L40 mm
Field of View	74deg. x 74 deg.
F value	1.7
Observable wavelength	450 – 750 nm
Resolution	0.65m @ 1000m
Sensor	CMOS, 1092x1092pix, 8bit
Spin rate	60-120 deg./sec