Success of a Laser Link Experiment with the Hayabusa2 Laser Altimeter

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The Hayabusa2 spacecraft, launched on December 3, 2014, is equipped with a laser altimeter called LIDAR. The laser altimeter is a ranging instrument which measures time of flight of laser pulses between spacecraft and celestial bodies with solid surface. Laser link experiments between the LIDAR and ground-based satellite laser ranging stations were conducted when the spacecraft was near the Earth before and after the gravity assist operation in December 2015, and uplink laser pulses from a ground station were successfully detected [1]. In addition to the main purpose of this experiment, which is the demonstration of the time transfer technique for onboard clock calibration, it was also a unique opportunity for the performance check of the instrument before arrival at the asteroid, including the alignment determination of the LIDAR field of view (FOV) axis with respect to the spacecraft.

To determine the FOV direction, the spacecraft was scanned spirally with 1 *mrad* step. Number of detection of the laser pulses at each spacecraft attitude by LIDAR is shown in Fig. 1. The yellow tiles correspond to the spacecraft attitudes where maximum number of laser pulses were detected. With this information, the FOV direction was determined with the accuracy of scan step size. Fig. 2 shows the reception level of the laser pulses by the LIDAR when we set the LIDAR to another observational mode (range mode). Because the intensity varied with the change of receiver gain and pointing shift of the ground-based telescope, we confirmed that the signals came from the ground-based laser, not from other sources such as Earth background radiation.

Hayabusa2 became the third spacecraft to establish a laser link at a distance farther than the Moon with a ground station, following the MESSENGER [2] and Mars Global Surveyor missions [3]. The farthest distance of successful experiment was 6.6 million km on December 19, 2015.

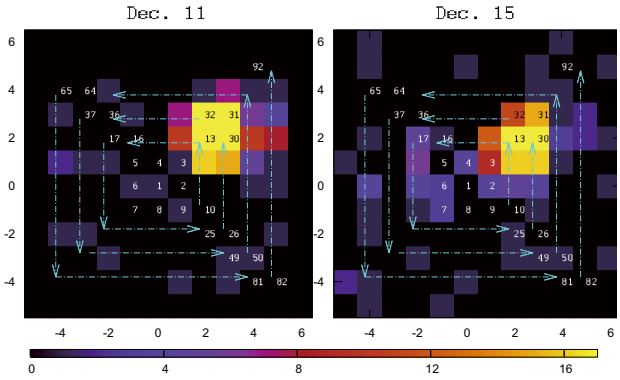

Figure 1: Number of signal detection with respect to the spacecraft scan direction on December 11 (left) and 15 (right), 2015 respectively [1]. Color shows the number of detection. The horizontal and vertical axes are the step sizes of the spacecraft scan, the directions of which nearly correspond to the right ascension and declination of the pointing direction, and the origin is the best-estimated direction of the boresight obtained during the ground-based prelaunch test. The maximum detection number for one tile is 17, because one data point was obtained within 2 seconds and spacecraft stayed one attitude for about 35 seconds.

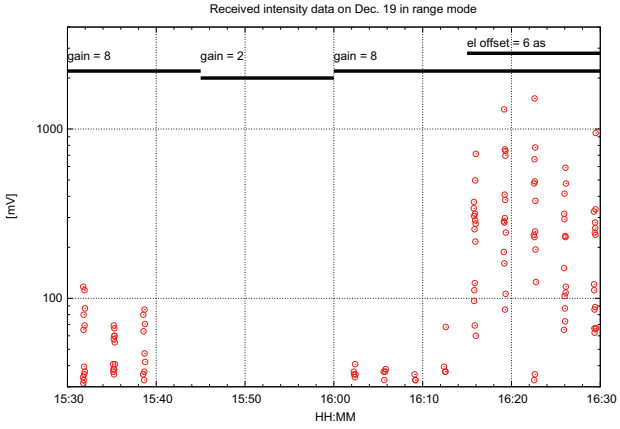

Figure 2: Intensity of the received pulses by LIDAR [1]. Experimental conditions of receiver gain ("high" = 8, "low" = 2) and the pointing offset of the ground telescope (el offset = 6 as) are drawn at the top. It is obvious that the reception level changes according to the changes of the observational conditions.

References

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