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Instrumentation and Observation of the XRS onboard Hayabusa: A CCD-based X-ray Fluorescence Spectrometer

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The XRS onboard the Hayabusa (MUSES-C), a Japanese asteroid explorer, has been developed to determine major elemental composition of the surface of asteroid through remote X-ray spectrometry. The XRS will observe asteroid 25143 Itokawa during the asteroid rendezvous phase, and it has additional chances to observe cosmic X-rays as well as the Earth and the Moon just before the Earth swing-by. We present the instrumentation of the XRS and discuss the recent results of observations from the viewpoint of design concept.

Design concept of the XRS is placed on better performance, smaller mass, and much reduced telemetry, since there exists severe constraint on them as a deep space mission. The XRS has been adopted new technologies and methods to improve its performance compared to that of the previous missions. We decided to use chargecoupled devices (CCD) since it has improved energy resolution when cooled. The XRS has been designed to mount four chips of 1-inch square sized two-dimensional CCD for main sensor (25 cm^2 in total) and another single one for solar X-ray monitor. To expand energy range and enhance detection efficiency in soft X-ray region, ultrathin beryllium windows of within 10μm thick are used. Onboard standard sample is prepared for real-time calibration of X-ray fluorescence excited by the sun. The XRS thermal design denotes the radiation cooling part where the CCD is mounted, along with the thermally isolated warm part including the electronics, resulting in the mass in 1.5kg of detector and in less than 3 kg of electronics. The method of onboard data analysis should be well designed and sophisticated to much reduce its telemetry. By use of logics with flexible programmable gate-arrays and onboard computer, the XRS has functions in histogram mode to extract X-ray events from all the CCD output data, classify them into grades, and make energy spectra for each grade in a given integration time. All CCD image data can be also available in diagnostic mode. This method reduces the telemetry by 5 or 6 orders of magnitude and has proven both in the laboratory and in space to almost keep its quality for elemental analysis. The concept has been also applied to the X-ray fluorescence Spectrometer onboard SELENE, a planned Japanese lunar orbiter.

Keywords: XRF; remote X-ray spectrometry; major elemental composition; CCD; Hayabusa; MUSES-C; asteroid; onboard data analysis; SELENE