Hayabusa XRS observation and current status

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The X-ray florescence spectrometer or XRS onboard Hayabusa has observed the first X-ray emission off the surface of lunar farside on May 17 in 2004, just before the Earth swing-by. The data indicates that the overall average composition of lunar farside is consistent with anorthosetic crust. We report the observation results as well as the configuration of observation. We also present the instrumentation and performance of the XRS.

The Hayabusa (MUSES-C) is a Japanese engineering experiment mission that will arrive a near earth asteroid 25143 Itokawa in 2005, perform scientific observation of the asteroid, collect samples from the uppermost surface, and return them back to the Earth in 2007. The XRS is a CCD-based X-ray spectrometer for remote XRF spectrometry. Solar X-rays irradiate planetary surface to excite each atom of the uppermost surface materials. Immediately those atoms settle to the ground state and X-rays characteristic of major elements are illuminated off the surface. Scientific objectives of the XRS are to determine surface major elemental composition of the asteroid and classify the asteroid into a meteoritic type. The XRS adopts new technologies such as charge-coupled devices for higher energy resolution, ultra-thin beryllium window for better transparency of soft X-rays and extend energy detection range of lower energy. It mounts a standard sample plate to calibrate XRF excited by solar X-rays.

Main observation phase of the Hayabusa will be planned during the asteroid rendezvous, but each instrument has been operated for its function and performance test during the cruising phase, especially around the earth swing-by, a gravity assist for spacecraft acceleration on May 19 in 2004. The XRS observation has been performed on May 17 that points the Moon. The viewing diameter of the Moon is about 0.6 degree, in which case the X-ray intensities of aluminum and silicon is estimated stronger than that of CXB and intense enough for detection by integration of five minutes. Indeed, the XRS has detected the XRF peaks of the two major elements with more intense than the continuum of CXB. The Hayabusa approaches the Earth and the Moon system from the sunward direction and at that time the Moon is located inside of the earth's orbit so that the XRS observed the farside of the Moon. Thus the XRS has observes the first X-rays off the farside of the Moon.

The XRS observes the X-rays off the lunar farside for about four hours on May 17 but those data obtained only in the last 30 minutes are effective for analysis. We have analyzed the data by subtracting the backgrounds and extracting the X-rays off the Moon. Two peaks at around the energy of 1.49KeV and 1.74 KeV are remarkably obtained, corresponding to Al-Ka and Si-Ka, respectively. Numerical simulation has been conducted for typical anorthosetic material and we found XRF peaks of Al and Si are two to three orders of magnitude more intense than the scattering solar X-rays. We compared the results of observation with that of our simulation and found a good agreement for the intensities and intensity ratio of the two major elements. Then we have concluded that the overall surface of lunar farside consists of anorthosetic material.

This first X-ray observation of lunar farside by the Hayabusa XRS is the pilot data, which will be soon followed by the first mapping observation with the D-CIXS onboard ESA's SMART-1 spacecraft from a large ecliptic lunar polar orbit (Grande et al., 2002). In a few years, the XRS onboard ISAS/JAXA's SELENE will map lunar surface with less than 20km spatial resolution through remote XRF spectrometry from 100km polar circular orbit (Okada et al., 2002). Similar lunar orbiter missions with performing XRF spectrometry are also planned by Chinese Chang'e and Indian Chandrajaan-1.

References: Grande, M., et al., ASR., 30, 1901-1907, 2002. Okada,T., et al., ASR., 30, 1909-1914, 2002.