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X-ray fluorescence spectrometer onboard MUSES-C: current status and observation plan

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X-ray fluorescence spectrometer, XRS, has been developed to determine major elemental composition of near-earth asteroid 1998SF36 through remote x-ray spectrometry in the Muses-C mission. As was proven during the Apollo 15 and 16 to the Moon and during the NEAR-Shoemaker to asteroid Eros(433), remote x-ray spectrometry can map surface major elemental composition, and will also take place in the Smart-1, Selene, Messenger, and Bepi Colombo.

In the previous planetary missions, proportional counters with balanced filters were used, and implicit uncertainty existed for elemental analysis. The XRS uses charge-coupled devices (CCD) to realize high energy resolution to discriminate line spectra characteristic to major elements. Electronics and software have been prepared for onboard data handling and analysis such as background rejection, x-ray event extraction, and pulse height analysis, due to huge data size per readout from CCD. Operation temperature below -40C is required for good performance of CCD, which has been achieved by thermal design of the XRS with least mass budget. By using the hood as radiator and with the chassis insulated from spacecraft, it has been examined that the temperature can be kept sufficiently cold. Development of ultra thin beryllium window has much improved statistical accuracy for faint x-ray fluorescence spectrometry, since transparency of soft x-ray such as Mg-Ka is greatly increased from 25% with 25 micron beryllium window in NEAR-Shoemaker to more than 60% with 5 micron beryllium in Muses-C. Direct monitoring of solar x-rays in the previous missions has intrinsic difficulty in quantitative elemental analysis due to the temporal variation and large energy dependency of solar x-rays, and also due to its methodology of fundamental parameters such as uncertain fluorescence yields. To avoid these problems, the XRS has a standard sample, and performs concurrent observation of x-ray emission from asteroid and from the standard sample to compare them, that is in situ calibration of x-ray fluorescence.

Current status of the Muses-C is in the middle of system integration test. The flight model of the XRS has been prepared after the component function and performance tests were successfully finished. During the performance test, we examine energy resolution, detection efficiency, charge transfer inefficiency, and their dependency on temperature. X-ray spectra from specimen with a variety of elemental composition have been observed with the XRS to construct methodology for quantitative elemental analysis. Observation sequences were also demonstrated in the laboratory with running the installed real operation program.

The objective of the XRS is to investigate relationship of surface materials to asteroid spectral types through remote x-ray spectrometry. That is among the most important information to be observed for exploration of primitive bodies to make a linkage of meteorites with asteroids. We have discussed on the accuracy of quantitative elemental analysis of asteroid during the Muses-C mission by comparing results of laboratory experiments of the XRS and numerical simulation with assumed condition of solar x-rays and surface materials. Determination of elemental ratios of Mg/Si and Al/Si are estimated within 5% uncertainty so that the asteroid can be classified into typical meteoritic groups, such as H- and L-chondrite. The XRS will observe x-ray emitting bodies and cosmic x-ray backgrounds during the cruising phase, which is utilized for in-flight calibration. Observation plan of the XRS will be presented in more detail.