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Development of a VIS/NIR Telescopic Imaging Spectrometer for the Moon

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Introduction:

We have been carring out Space Station Lunar Observatory project. The sensitivity of space-borne imaging instruments fall several % - several tens of % after the launch. A purpose of this project is to establish the photometric model of the moon as a spectral radiance standard of space-borne imaging instruments by repeated observation of the moon with a VIS/NIR (Visible and Near Infra-red light) Telescopic Imaging Spectrometer going to be installed on the Japanese Experiment Module (JEM) Exposed Facilities (EF) of the International Space Station (ISS). We started for this project the development of a ground-based model of the Telescopic Imaging Spectrometer in cooperation with Kawasaki Steel Techno-research Corporation. This project is carried out as a part of 'Ground-based Research Announcement for Space Utilization' promoted by Japan Space Forum.

Telescopic Imaging Spectrometer:

The VIS/NIR Telescopic Imaging Spectrometer is composed of three elements; telescope, moving mirror, and line spectrometer. There are two line spectrometers for VIS (380-1060nm) and NIR (1000-2400nm) respectively. At present, however, only VIS system has been developed and NIR system will be partly developed (1000-1700nm) this summer. The system of spectrograph is Prism-Grating-Prism type. The telescope is Cassegrain type. The aperture is 200mm and focal distance is 800mm. The line spectrometer has only 1-dimension spatial resolution, therefore a moving mirror scans the image. The moving mirror is used for selecting a sensor (live monitor, VIS system, or NIR system) too. The set of VIS and NIR line spectrometers covers 380nm-2400nm and the target time for scanning a image is less than 10 minutes.

Field integrating sphere:

The accuracy of observation by imaging devices is influenced by the quality of flat field. With a flat field image, image artifacts such as camera shading inherent in imaging systems and artifacts induced by minute dust specks located in the optical path can be removed. Sensibility deflection between CCD pixels can also be corrected. The portable field integrating sphere was developed for getting clear flat-field images in the open air at night (Saiki et al., 2001). Two styrene foam hemispheres were connected and five electric bulbs (krypton lamp) were attached. The inside of the sphere was painted with white house paint. Several house paints were measured their photometric characteristics by Multi-Spectro radiometer MSR-7000 and the most diffusive reflector was selected. For the ground-based VIS/NIR Imaging Spectrometer, a field integrating sphere, 90cm in diameter, was made. It costs only $200.

Calibration:

To calibrate spectral data, spectra of standard stars are used. To make photometric correction, two softwares, LunarFilter (LF.EXE) and LunarMap (LM.EXE), are prepared. LunarFilter makes an image composed of photometric correction factor from the record of observation (lunar diameter on the image, libration, co-longitude, and phase). LunarMap makes the template including control points showing how to put the filter on the lunar image. Phtometric correction factor is calculated by the equation of Yokota et al. (1998).

Application:

The Telescopic Imaging Spectrometer can be applied to many other studies. The know-how acquired through the development of image-analysis method for hyper spectral image will be applied to the SELENE project (Japanese lunar mission). Obtained hyper spectral images of the moon will be useful for estimate of the lithology and chemical compositions of the lunar surface and for study of the evolution process of the crust of the moon. We plan to try the calibration of SELENE LISM (Lunar Imager and Spectrometer) by simultaneous ground-based observation of the moon.