SPECTRAL INVESTIGATIONS OF THE MOON WITH THE SMART-1 NEAR INFRARED SPECTROMETER SIR

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Introduction / Overview: SIR is a highly compact grating, near infrared spectrometer which covers the wavelength range between 0.94 and 2.40 µm. The instrument is a technical experiment on board of SMART-1 and has been built by a consortium led by the Max-Planck-Institut für Aeronomie. The main scientific goal of the spectrometer is to determine the Moon's mineralogical composition. SIR will map as the first NIR spectrometer the Moon's surface including the South Polar Region and the farside with an unprecedented high spatial (up to 310 m) and spectral resolution ($_{pixel}$ 6 nm). In the lunar observation phase SIR will scan the surface primarily in burst mode while the spacecraft is orientated in nadir pointing. This mode allows us to take large amounts of spectra on short and long time-scales. In dedicated stages of the mission SIR will be pointed toward targets of special interest. This mode allows observations of extended periods (up to 10 s) including the possibility to increase the signal to noise ratio by spectra averaging. The mode is in particular important for the search of possible ice formations in permanently shadowed depressions at the lunar poles.

Expected Scientific Output: SIR's great advantages compared to ground-based instrumentation is its high spatial resolution, its ability of observing the lunar far side and that its spectra will not be affected by atmospheric absorptions and emission lines. SIR will be able to take several hundred thousands of spectra in the nadir-pointing mode from different surface features. The following list gives a partial overview of the expected contribution to lunar exploration.

Maria: The mare basalt distribution, especially of the lunar far side, where the compositional spectral analysis was up to now limited by the Clementine UVVIS "five-filter" approach will be spectrally mapped. SIR data will provide new insight in the characteristics of this region of the Moon. The far side is very interesting from the point of view of lunar basalt petrogenesis. In contrast to the near side, the far side has two large-scale terrains which are different in the structure of lunar crust: 1) the northern far side where the crustal thickness is the largest on the Moon, and 2) the southern far side where the crust is anomalously thin.

Highlands: The mapping will reveal the compositional variations of the lunar highlands. These variations reflect the complex interplay of magmatic and impact events. Since impact reworking can not hide the regional to global compositional characteristics of the upper layer of the lunar crust, such as the mean percentage of anorthositic feldspar or mafic minerals, this puts serious constraints on the models of the early large-scale differentiation of the Moon. For example the abundance of plagioclase in the highland crust may be a test to distinguish between the Magma Ocean and serial magmatism hypotheses for the formation of ferroan anorthosites.

Basins / Impact Craters: Simple to complex crater structures will be detailed in their mineralogical composition. The excavation of the target material and its deposition in the form of ejecta blankets, and the uplifting of crater floors that lead to the formation of central peaks (in large craters) and inner rings (in even larger impact basins) are unique possibilities of studying lower crust and potentially upper mantel material. The most interesting target in this context is the South Pole Aitken basin. Furthermore, the study of crater features allows the reconstruction of the pre-impact lithology which will shed more light into cratering processes.

Space Weathering Effects: The surface material of airless planetary bodies is affected by physical and chemical changes induced by electromagnetic and particle irradiation as well as meteoritic bombardment. Regolith, exposed on the lunar surface, lowers its albedo, reddens the spectral slope and masks absorption bands. The determination of the mineral composition of the lunar surface requires therefore the consideration of maturation. By comparing spectra of small craters from different ages we intend to derive more detailed information about the maturation process of the regolith and to consider these results for the mineralogical analysis.

Individual targets of special interest: A set of individual unusual targets, like for example swirls, pyroclastic deposits, areas of very young mare volcanism, localities of nonmare basalts and the landing sites of Apollo and Luna missions have been selected for detailed observation. The latter ones will be used for cross calibration. We expect the discovery of small scale areas of mantle material deposition (basalts, volcanic ashes, and pyroclasts) which deliver informations about the Moon's internal constitution and thermal history. Beside this we intend to point SIR to permanently shadowed crater floors at the poles to search for spectral features of ices.

Table: Characteristics of SIR:

Wavelength Range	0.94 – 2.40 m
Spectral Resolution	$_{pixel}$ 6 nm
Quantum Efficiency	0.06 to 0.11
Angular Resolution	1.11 mrad
Aperture / f-ratio of Optics	72 mm / 2.5
Integration Times	0.1 to 528 ms
Power	4.4 W + 1 W heater

Figure: Main instrument unit (PFM) with front-end optic and spectrometer (background)