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Laboratory measurements in support of the DAWN mission: the SPectral IMaging (SPIM) facility.

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Introduction

The SPectral IMaging (SPIM) facility is a laboratory set-up that has been developed to support remote sensing observations of Solar System bodies. In particular, the SPIM facility will be extensively used to support the DAWN mission[1], now approaching Vesta. The core of SPIM is a spectrometer that is a replica of the Visible InfraRed imaging spectrometer (VIR) [2], onboard the DAWN spacecraft. The SPIM spectrometer has been assembled and calibrated at Selex Galileo (SG) and then installed in the facility in the INAF-IFSI laboratory in Rome. SPIM has two goals: collect data to prepare a data-base of reflectance spectra for the interpretation of the space borne measurements; functional tests to simulate VIR operative conditions during the mission.

1. Instrument set-up

The VIR replica available in SPIM is a spectral imager that covers the 0.25-5.05 μm spectral range, with 38 μm of spatial resolution on the target. The spectral coverage is obtained with the integration of two bi-dimensional focal planes, one for the visible between 0.25 and 1.05 μm and one for the IR between 0.95 and 5.05 μm. The bi-dimensional focal planes aligned with the spectrometer's slit axis permit the acquisition of the target's image at different wavelengths. To reduce the background noise due to thermal emission, the spectrometer and the IR detector need to be cooled at 130K and 80K, respectively. To avoid vapour condensation when at the operative temperature, the spectrometer has been installed inside a thermo vacuum chamber (TVC) chilled by liquid nitrogen. The spectrometer has the same optical layout of VIR (Offner grating Spectrometer [3]) but the optical system used to focus the beam coming from the target on the entrance slit of the spectrometer is different. As VIR observe targets at infinite distances is necessary to use a telescope to collect and focus the collimated beam on the entrance slit of the spectrometer. On the contrary, as SPIM observes targets placed at finite distances, is necessary a focusing optical system to collect the diverging beam. Moreover, the scanning systems of the two spectrometers are different. VIR has a scanning system on the primary mirror used to perform push broom acquisitions, while SPIM acquires hyper-spectral cubes observing the target moving on a scanning sample holder.

The optical system of the SPIM facility has been designed to collect the signal from the target outside the TVC, and to focus the beam on the entrance slit of the spectrometer inside the TVC. The presence of the CaF_2 window in the optical path has required the development of a specific optical system. In order to minimize the aberrations induced by the window of the TVC, the optical beam is collimated by a parabolic off axis mirror outside the TVC and then a twin mirror inside the TVC converges the signal on the entrance slit of the spectrometer.

The sample holder is composed of a three axis translation stage. All stages are motorized and programmed via PC. The scan along the optical axis of the system (Z axis), is used to place the surface of the target in the focal plane of the external parabolic mirror. Afterwards, in order to perform a hyper-spectral cube, the scanning system moves the target with a step of 38 μm for each signal acquisition in the direction across the slit axis (Y axis). The value of the step matches the dimension of the slit in the X axis (38 μm).

2. Spectrometer calibration

The imaging spectrometer has been assembled and calibrated at SG. After the integration of the spectrometer in the SPIM facility in the INAF-IFSI laboratory, the calibration has been repeated and completed in order to consider any possible influence

Spectral: The purpose of the spectral calibration is to verify the spectral performances of the facility. At SG the spectral calibration was done performing spectral scans using a monochromator. At INAF-IFSI such results have been verified using a HgNe pencil lamp (Oriel model n° 6034). In figure 1 the spectra of the HgNe lamp for the two focal planes are shown in arbitrary units (the visible channel at the top and the IR channel at the bottom). The emission lines of the lamp are evident.

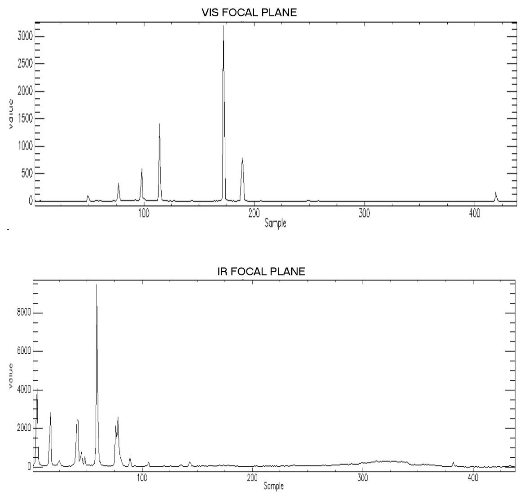

Figure 1: HgNe pencil lamp emitted signal acquired on the Visible focal plane (top) and on the IR focal plane (bottom)

From a preliminary analysis the lines are shifted by 5 bands (= 10 nm) with respect to the SG calibration probably due to a difference in the spectrometer's temperature for the two set-ups. In table 1 there is a summary of the spectral calibration results.

	VIS	**IR**
Resolution (nm)	2.1±0.1	12.5±0.1
Range (nm)	(222 - 1049) ±1	(973 - 5107) ±1
Sampling (nm)	1.89±0.05	9.46±0.05

Table1: Spectral calibration results.

Geometrical: In order to obtain the geometrical calibration a standard USAF 1951 Resolution target from Edmund Optics has been used. In figure 2 there is the target's image at 545.6 nm acquired by the VIS channel. The preliminary analysis shows a spatial resolution of 40 μm. A summary of the geometrical calibration results is reported in Table 2.

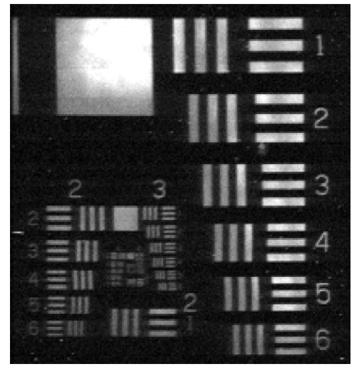

Figure 2: An image at 545.6 nm of the geometrical calibration target USAF 1951.

	VIS	**IR**
I-FOV (μm)	40±1	40±1
FOV (mm)	9.9±0.5	9.9±0.5
Sampling (μm)	38.5±1.0	38.5±1.0

Table2: Geometrical calibration results.

6. Conclusions

The SPIM facility is ready to collect reflectance spectra of mineral samples analogous to those found on surfaces of Solar System bodies, such as the main targets of the Dawn mission, Vesta and Ceres. Laboratory measurements with an imaging spectrometer similar to the one flying on Dawn will be helpful for the analysis an interpretation of data that will be acquired during the mission.

Acknowledgements

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References

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