VIS-IR SPECTRAL IMAGING OF VESTA: THE VIR EXPERIMENT

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Introduction: VIR, the Visible InfraRed mapping spectrometer, is one of the three scientific experiments aboard the Dawn mission designed to characterize the composition of the Vesta surface [1]. The instrument performs imaging spectroscopy in the range from the near UV (0.25 µm) through the near IR (5 µm) and has moderate to high spectral resolution and imaging capabilities. The asteroid surface composition can be identified thanks to visual and infrared spectral features. Moreover the instrument can discriminate compositional classes through the identification of these features on the surface, thanks to the imaging capability.

VIR instrument: The VIR experiment (see Figure 1) aboard the Dawn mission is an advanced VIS-IR imaging spectrometer [2]. VIR mapping spectrometer combines two data channels in one compact instrument. The visible channel covers 0. 25–1.05 µm and the infrared channel covers 1.0–5.0 µm (table 1). These characteristics make it an appropriate instrument for determining the Vesta's global surface composition.

		VIS channel	IR channel
Spectral Performances	Spectral range	0.25 -1.05 µm	1.0-5.0 µm
	Spectral sampling (high res)	1.8 nm/band (432 bands)	9.8 nm/band (432 bands)
	Spectral resolution $\lambda/\Delta\lambda$	100 -380	70 -360
Spatial Performances	IFOV (high res)	250 × 250 µrad	
	FOV (high res)	64 × 64 mrad	

Table 1: VIR instrument performances.

VIR Spectral Imaging: The nature of the solid compounds as well as the mineralogical composition of of the Vesta surface can be identified by visual and infrared spectroscopy using high spatial resolution imging to map the heterogeneity of asteroid surfaces and high spectral resolution spectroscopy to determine the composition unambiguously. Moreover the possibility to acquire spectral images in the visible and infrared regions could give information on the spatial distribution of different minerals on the asteroid surface. Simultaneous spectral resolution and spatial resolution are needed to investigate surface geology, making possible the identification of mineralogical provinces, and producing compositional maps. Such maps will provide information on the relationship between global and local spectral characteristics.

Figure 1: VIR optical head during pre-launch tests (Image courtesy Selex Galileo).

Objectives: One of the main goals of Dawn is to determine the mineral composition of the surface and to place it in geologic context. Several diagnostic absorption bands for key minerals occur in the visible and near-infrared regions and can be identified with spectroscopic measurements.
Common rock-forming minerals in both meteorites and asteroids exhibit distinctly different and diagnostic absorption bands. The wavelength, shape and strength of various absorption features are determined by the minerals and molecules possibly present on the first micrometers of the surface. Each parameter must be measured accurately to make identifications and derive relative abundances.

The VIR mapping spectrometer has the resolution and accuracy necessary for this inversion process. Methods for compositional information extraction range from straightforward linear or nonlinear mixing models of multiple components to a more sophisticated quantitative analysis of individual absorption features.

Maps of the current surface mineralogy lead to the understanding of the surface evolution and determination of the processes affecting it. VIS and Near IR spectroscopy contribute to asteroid studies by delineating absorption features which are not resolved with broad band filters and by refining the measurement of differences in spectral shape such as band depth and width.

The VIR excellent image capability will give important information on surface geology through the production of mineralogical maps, to be associated with the morphological information of the surface given by imaging generated both by VIR and by the camera.VIR will produce maps at different resolutions, depending on the height of the orbits, therefore global mineralogical characteristics of the surface will be complemented by local detailed information gathered on lower orbits.

VIR observation strategy at Vesta: The acquisition strategy is based on the constraints and requirements for the Survey phase. The main constraints are imposed by the limitations of the onboard memory (Virtual Recorder of S/C and VIR memory), illumination conditions, orbit maintenance manoeuvre, download, and by the need to collect images for optical navigation.

The Dawn mission, as most of the NASA Missions will be considered successful if a certain number of data are correctly collected. These minimum scientific requirements, are called "Level-1 requirements". The Level-1 requirements for VIR instruments are to obtain > 5000 VIR spectra with high spectral/high spatial resolution (resolution of <800 m). Moreover , the second requirement is the a complete global mapping of Vesta's spectral variation. Global mapping is also needed to plan for later targeted imaging.

The observation strategy has been built taking care of the residence time, e.g. dwell time, of the scene in the VIR IFOV, the integration and repetition times, global coverage, data storage and dump in VIR and S/C memories, global coverage and redundancy. In Table 2 are indicated the typical spatial resolutions expected during the different phases of the mission at Vesta. During the Survey phase, VIR observations are planned only for solar phases <60°.

Orbital phase	Orbit altitude	Spatial resolution
Survey	≈ 2700 km	< 750 m/pixel
High Altitude	≈ 700 km	< 220 m/pixel
Low Altitude	≈ 200 km	< 100 m/ pixel

Table 2: VIR expected spatial resolution during the different phases of the Dawn mission at Vesta.

Conclusions: VIR will map, with a spatial resolution of a few tens of meters, the Vesta surface and will determine the spatial distribution of the various mineralogical types and their mixtures using both the spectral features and the overall brightness.

At Vesta, VIR capabilities will confirm whether or not a exist link between Vesta and the HED meteorites and will establish the abundances and mineralogy present on Vesta surface sufficiently to understand the source of meteorites recovered on Earth.

Moreover will be possible to obtain the first in-depth view of a planetary interior through the spectral imaging of Vesta's wide and deep impact basin and to reveal the nature of Vesta's ancient magma ocean or volcanic emplacement history. Finally, VIR will solve the issue of the identification of space weathering on the observed surface.

References: [1] Russell, C. T. et al. (2007), Earth, Moon, and Planets, 101, Issue 1-2, pp. 65-91. [2] M. C. De Sanctis (2010), SSR, 10/2010, doi: 10.1007/s11214-010-9668-5.