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Spectral diversity of Ceres surface as measured by VIR

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1. Introduction

The Dawn spacecraft (1) has been acquiring data of dwarf planet Ceres since January 2015 (2). During the approach maneuver (January to April 2015), there were nine opportunities – called OpNavs or RCs - to point the optical instruments towards Ceres and to acquire spectral information of its surface. These opportunities differ in resolution, illumination conditions and sub-spacecraft point (Table 1). In late April/early May 2015, the instruments performed an observation campaign while the spacecraft was in orbit around Ceres at an altitude of about 13600km. In this mission phase – called RC3 – the instruments acquired Limb and High Phase images while the spacecraft was in the night side of the orbit and nadir images while it was in the day side. In three consequent orbits scheduled to start respectively early in June (Survey, 4400 km altitude); early in August (HAMO, 1470 km altitude); early in December (LAMO, 375 km altitude) the instruments will acquire data in the dayside section of the orbit at increasing resolution.

2. VIR measurements at Ceres

The spectrometer VIR (spectral range: 250-5000nm) (3) acquired data during all OpNavs and RCs. It will continue its measurements during Survey, HAMO and LAMO (4). VIR is observing compositional variability all across the surface of Ceres since data acquired in RC2 (March 2015) (5). The spectral diversity of Ceres is confirmed by color filters data acquired by the Dawn camera (6) (7). The variability is particularly evident in changes of the shape of the spectra in the range from 500nm to 4000nm. Outside this range, the data have not been considered in this first step of the analysis because they are difficult to handle: in the short wavelengths side (250nm-500nm) due to a drop in the sensitivity of the instrument; in the long wavelengths side (4000nm-5000nm) due to the thermal emission from Ceres (8).

The spectral slope in addition to center and depth of absorption bands in the considered spectral range have been computed and mapped. In figure 1 there is an example of a VIR image acquired during RC3. In the image there are still several artifacts evident as vertical columns. However, it is possible to identify an underlying variability that sometime is associated with high reflectance regions (circle A) but not always (circle B). In figure 1 central panel (RGB in the VIS range), regions in orange have a higher level of reflectance in wavelengths around 550nm in comparison with the 1000nm range. On the contrary, the bluish regions have a smoother behavior all along the 550-1000nm spectral range. The image also has an extended reddish region in the left side; however, considering the acquisition geometry, this is likely a residual of the photometric correction. The Green channel used in the composition of the image (ratio 965/830) does not show a significant variability in this specific cube indicating a weak correlation between the spectral shape in this section of the VIR sensitivity range and the properties of the surface of Ceres. On the contrary, in the bottom panel (RGB in the IR range) most of the variability is in the Green (ratio 2660/1200) and Blue (ratio 2730/2660) channels. This is an indication that in the IR range, wavelengths above 2500nm are the most correlated with the composition of Ceres.

Table 1: Characteristic of the VIR observations during the approach of the Dawn spacecraft to Ceres. OpNav is short for Optical Navigation, RC is short for Rotational Characterization. OpNavs are activities of about one to two hours, RCs last enough time to give the instruments the possibility to acquire data for a full rotation of Ceres.

	VIR Resolution (km)	Phase Angle (deg)	Sub-Solar Latitude (deg)
OpNav1	95	27	-28
OpNav2	60	23	-26
OpNav3	37	19	-22
RC1	22	17	-16
RC3	11	47	8
OpNav4	10	92	29
OpNav5	13	126	34
OpNav6	8	126	57
OpNav7	6	81	77

3. Figures

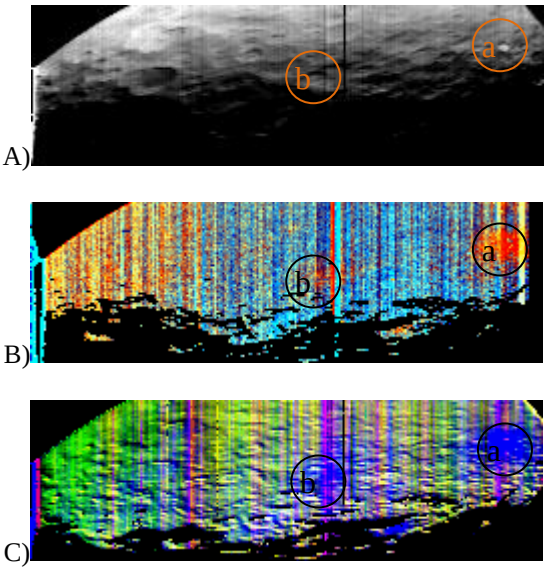

Figure 1: Images of a Spectral Cube acquired during RC3 (about 3.4km/px). Top image is I/F at 1200nm in grey scale. Central panel is an RGB combination of band ratios in the VIS range (R: 550/830, G: 965/830, B: 965/550). Bottom panel is an RGB combination of band ratios in the IR range (R: 2000/1200, G: 2660/1200, B:2730/2660). All the wavelengths are in nm.

4. Summary and Conclusions

In summary, according to VIR measurements, Ceres surface has a compositional variability already evident in the 3.5Km/px spectral images acquired in RC3. Analysis of the spectra is still going on and for a detailed compositional assessment higher resolution data are needed. However, already in the RC3 images, it is clear that the 3000nm range is the section of the spectrum that has the highest correlation with the composition of the surface although variations are present also at shorter wavelengths. This is a confirmation of the intriguing nature of the spectrum of Ceres in the 3000nm range already evident in pre-Dawn observations (9).

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