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The Color of 4 Vesta and Lithology Diversity: First Results from Dawn Survey Orbit

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Abstract

The FC cameras onboard the Dawn spacecraft are expected to map the asteroid 4 Vesta in seven different colors from Survey Orbit in August 2011. We will present the first immediate results of the spectral mapping of the visible surface from FC images along with their association with surface compositional units. The first medium resolution observations of Vesta have been performed in July 2011(Fig.1).

Fig. 1: Dawn FC clear filter image of Vesta obtained on July 18, 2011. Image credits: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA.

1. Introduction

4 Vesta is the largest differentiated asteroid [1] that is still mostly intact today and is considered to be a model for the initial stages of planetary differentiation (e.g., [2]; [3]; [4]). NASA's Dawn mission has been captured in July 2011 by Vesta for a yearlong global characterization. The Framing Cameras (FC) onboard the Dawn spacecraft (Fig. 2) will image the asteroid in one clear and seven narrow band filters (Fig. 3) covering the wavelength range between 0.4-1.0 μm. The Framing Cameras [5] have been developed and built under the leadership of the Max Planck Institute for Solar System Research, Germany, with significant contributions by DLR Institute of Planetary Research, Berlin, and in coordination with IDA, Braunschweig.

We present the first results from the Dawn FC color observations of 4 Vesta obtained during the Approach and Survey phases, which will be completed by August 2011. Our aim is to address some basic questions related to Vesta's surface compositional diversity and the processes acting on it, in the context of its geology, for example:

- Are large-scale albedo variations on Vesta related to color/compositional units; is the hemispherical dichotomy confirmed?
- What are the distinct color units on Vesta and how do these color variations relate to geologic features of the surface?

- Can known HED meteorites serve as a ground truth for some identified color units?

- What new or different lithologies not present in the terrestrial meteorite collections might occur on Vesta and what is their geologic context?

Fig. 2: DAWN Framing Camera with removed MLI.

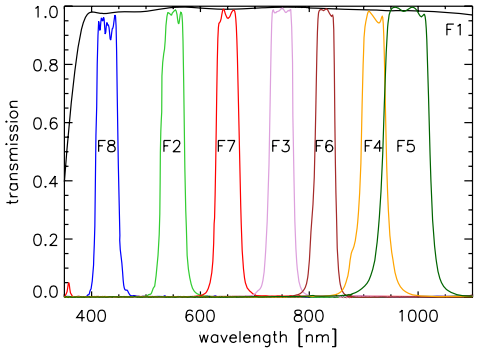

Fig. 3: Transmission profiles of the FC filters.

2. Color-Albedo Variations of Vesta

As measured with telescopes from Earth, Vesta's integrated lightcurve in the visible wavelength range shows a single maximum and minimum per rotation unlike most other smaller ellipsoidal asteroids. This is due to rotational albedo variations across Vesta's surface contributing more to the lightcurve than its triaxial ellipsoid shape, and one hemisphere inherently being brighter than the other (e.g., [6]; [7]). [2] suggested that the darker hemisphere could be due to an 'age-related darkening effect' and correlated a decreased band depth with the lightcurve minima. [8] also noted a similar relationship between albedo and absorption band depth in Vesta's Southern Hemisphere and attributed this to a change in pyroxene chemistry.

The Dawn FC color observations are expected to be able to distinguish between eucrite/diogenite terrains and can assess if the albedo dichotomy variations are due to color (compositional), or space weathering processes and/or a recent resurfacing event.

3. Distinct Color Units

Ground-based telescopic spectral measurements and HST color observations of Vesta (e.g., [7]; [2]; [8]; [9]) indicate several distinct compositional and color units that stand out above the background terrain/colors (assumed to be howardite or polymict eucrite). The character, distribution, and geologic context of these materials hold the key to understanding the geologic history of Vesta. Direct comparison of FC color maps of Vesta from Survey Orbit with the earlier HST color maps and ground-based spectroscopy will set the framework to understand the true nature of these color units as the exploration of Vesta commences. These initial Dawn data could also possibly detect new lithologies that cannot be resolved by telescopes.

We will apply a variety of analysis tools to the initial Dawn multicolor data for Vesta. These include standard imaging processing procedures (PCA, mixing analyses, etc.) as well as evaluation and manipulation of color ratios and spectral parameters that are linked to mineralogy (HED components, etc.) and/or surface processes (space weathering, texture, etc.). The tools we intend to apply include "DawnKey", an automated lithology identification software (Le Corre et al., 2011, EPSC/DPS 2011) that allows us to identify spectrally distinct units by using a HED and non-HED spectral library, and Automated Spectral System (ASS), a terrain mapping system based on pyroxene mineral chemistry (Reddy et al., 2011, EPSC/DPS 2011).

References

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