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The Global Photometric Properties of Vesta: First Results from Dawn's Approach and Survey Orbit

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Abstract

During the approach and the Survey Orbit near Vesta, Dawn spacecraft collected visible images through a clear filter and seven color filters from 430 nm to 980 nm and near infrared spectral cubes from 1 µm to 5 µm, with a minimum pixel scale of less than 300 m/pixel in the imaging data, and covering a wide range of phase angles from ~8º to ~108º. We hereby report the first results of the global photometric properties of Vesta.

1. Introduction

Photometric analysis separates the fundamental properties of a surface from the effects of scattering geometry due to topography. Both the composition and the geological processes change photometric properties such as albedo, opposition surge, phase function, as well as photometric roughness. Surface photometric properties determine the reflectance of a surface under any illumination and observing geometries. Good photometric modeling therefore not only provides us with the important clues of composition and geological processing, but also ensures the best removal of topographic effects from the fundamental properties of the surface. This is essential for the quality of photometric corrections and mosaicking of images and spectral cubes, and for various compositional and geological studies of the surface of Vesta. We construct and maintain a photometric model of Vesta before Dawn's arrival and throughout the stay at Vesta.

1.1 Pre-Dawn photometric model

In order to validate the photometric model of Vesta derived from Dawn data, and to determine the best exposure times for Dawn imaging and spectroscopic instruments, we constructed a pre-Dawn photometric model of Vesta by combining various ground-based data. The phase function constructed from ground-based observing campaign of vestoids, which are considered as being ejected from Vesta, is shown in Fig. 1. This phase function model is consistent with an IAU HG phase function model with a G parameter of 0.28. Ground-based data are also collected through all Dawn Framing Camera (FC) color filters and confirmed that there are no apparent changes of phase function with respect to wavelength in the visible wavelengths. Hubble Space Telescope observations of Vesta provide the pre-Dawn surface albedo models of

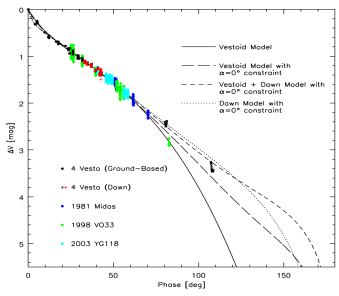

Fig. 1. Phase function of Vesta from Dawn data, compared with the models from vestoids.

Vesta [1,2].

2. Photometric modeling

2.1 Disk-integrated phase function

Dawn spacecraft continuously collected data during approach and at Survey Orbit. The images with Vesta

smaller than the field-of-view (FOV) are at phase angles higher than ~23º, and are used to measure the disk-integrated phase functions of Vesta. After the corrections to the apparent cross-sectional area of Vesta at the corresponding spacecraft latitude, assuming an oblate shape with an equatorial radius 289 km and a polar radius of 229 km [4], the phase function of Vesta agrees with the pre-Dawn photometric model at phase angles lower than 80º, but appears to be brighter than the model at higher phase angle (Fig. 1). The relatively stronger forward scattering of Vesta's surface than vestoids could be due either to the more forward scattering particle phase function of Vesta, or to smoother surface on Vesta than on vestoids.

2.2 Disk-resolved modeling

The high spatial resolution of the data collected in late approach and at Survey Orbit allow us to model the limb-darkening properties and the phase function of Vesta using all the images within the whole range of phase angles to study the surface roughness and photometric variations. We performed disk-resolved photometric modeling with various models. The local scattering geometry is calculated with the shape model of Vesta developed from Dawn data.

Hapke's modeling on Vesta results in an average surface photometric roughness of ~20º, independent of wavelengths. This is slightly higher than the values reported from Hubble Space Telescope (HST) observations, and the difference is probably due to the much lower spatial resolution of HST images [2]. The single-particle phase function parameter of a single-term Henyey-Greenstein function is from ~-0.26 at 440 nm to ~-0.23 near 950 nm. The slightly shallower phase function at longer wavelength is consistent with the phase reddening in visible and the near infrared observed from the ground. The single-scattering albedo is consistent with the previous observations from the ground and from HST [5]. Vesta displays large photometric variations on the surface.

3. Discussions

The photometric properties of Vesta are similar to those of vestoids. This is consistent with vestoids being derived from Vesta by impacts. The stronger forward scattering of Vesta compared to vestoids is consistent with smaller particle sizes on Vesta, presumably due to relatively stronger gravity on Vesta being able to retain smaller particles. The packing status of the regolith particles could also contribute to the difference between Vesta and vestoids. With a high single-scattering albedo of Vesta, ~0.6 at 600 – 700 nm wavelength, multiple scattering might play a significant role on the scattering properties of Vesta's surface. This might also contribute to the relatively strong forward scattering on Vesta.

Compare with most asteroids and the Moon, Vesta is bright. The brightness might be related to relatively fresh surface of Vesta with less weathering. The expected strong multiple scattering might require a different modeling process from other darker asteroids and for the production of albedo maps.

4. Summary and Conclusions

We performed photometric modeling of Vesta with Dawn data collected during approach and the Survey Orbit. The photometric properties of Vesta derived from Dawn are consistent with those previously derived from the ground and from vestoids. The single-scattering albedo of Vesta is ~0.6, relatively high compared with most other asteroids and the Moon. The phase function of Vesta displays a weak dependence with wavelength, consistent with phase reddening. The Hapke's roughness of Vesta is ~20º, and independent of wavelengths. Vesta shows a slightly stronger forward scattering than vestoids, presumably due to its bright surface and smaller particle size than those of vestoids.

Acknowledgements

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