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Ceres Photometry and Albedo from Dawn Framing Camera Images

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1. Introduction

The Dawn spacecraft is in orbit around dwarf planet Ceres. The onboard Framing Camera (FC) [1] is mapping the surface through a clear filter and 7 narrow-band filters at various observational geometries. Generally, Ceres' appearance in these images is affected by shadows and shading, effects which become stronger for larger solar phase angles, obscuring the intrinsic reflective properties of the surface. By means of photometric modeling we attempt to remove these effects and reconstruct the surface albedo over the full visible wavelength range. Knowledge of the albedo distribution will contribute to our understanding of the physical nature and composition of the surface.

2. Photometric Modeling

The availability of images acquired at a range of illumination geometries allows the construction of photometric models for the reflectance (r_F) of the surface. We employ models that can be separated into a phase function (A_{eq}), describing the brightness as a function of phase angle (α), and a disk function (D), describing the brightness as a function of incidence and emission angles (ι, ε) [2]:

$$r_F(\iota, \varepsilon, \alpha) = A_{eq}(\alpha)\, D(\iota, \varepsilon, \alpha).$$

We evaluate various disk functions (Lambert, Lommel-Seeliger, Minnaert, Akimov) for their effectiveness and determine the phase function for each of the FC filters. We address how the photometric model parameters may provide insight into the physical properties of the surface.

3. Surface Albedo

Once a photometric model has been established, we can photometrically correct the images. This involves dividing the observed image by a model image, calculated from the photometric angles given by a shape model (Fig. 1). We use a shape model provided by JPL and project the images using the USGS ISIS software. In principle, after photometric correction the brightness distribution is governed by the intrinsic reflective properties of the surface material, i.e. the albedo. In reality we also deal with pointing inaccuracies and imperfections of the shape model and the photometric model.

Figure 1: An example of photometrically correcting a Framing Camera image of Ceres. At left the original image as acquired on approach, in the center a model image, at the right the ratio of the two, showing the albedo distribution over the surface.

On approach to Ceres, the FC imaged the surface at relatively low phase angles, for example during the RC1 phase, which favors the albedo reconstruction. We use these images to construct an albedo map of the surface. In light of the detection of water around Ceres [3], which suggests the dwarf planet is active, it is worthwhile to compare our map to previous maps made from HST [4] and Keck [5] images, and evaluate whether any surface changes occurred over the last decade. This requires degrading the FC map resolution to match that of the other instruments, preferably by means of convolution with the point spread function.

4. Summary

We construct photometric models for the surface reflectance of Ceres. We employ these models to photometrically correct Dawn Framing Camera images and use these to map the albedo. We compare our map to existing albedo maps to identify any surface changes.

References

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