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# Photometric Properties of Ceres and Comparisons with Previous HST Observations

**Jian-Yang Li** (1), Andreas Nathues (2), Lucille Le Corre (1), Vishnu Reddy (1), Mark V. Sykes (1), Martin Hoffmann (2), Stefano Mottola (3), Stefan E. Schröder (3), Andrea Longobardo (4), Mauro Ciarniello (4), Lucy A. McFadden (5), Carol A. Raymond (6), and Christopher T. Russell (7)
(1) Planetary Science Institute, USA, (2) Max Planck Institute for Solar System Research, Germany, (3) Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany, (4) Istituto di Astrofisica e Planetologia Spaziali, Istituto Nazionale de Astrofisica, Rome, Italy, (5) NASA Goddard Space Flight Center, USA, (6) Jet Propulsion Laboratory, California Institute of Technology, USA, (7) Institute of Geophysics and Planetary Physics, University of California, Los Angeles, USA.

## 1. Introduction

NASA's Dawn spacecraft entered the first science orbit around its second target, dwarf planet Ceres, in April 2015. The photometric properties of Ceres not only reveal clues about the physical state of the regolith, surface composition, and geological history, but also are important for correcting the data collected under various observing and illumination geometries to a common geometry to facilitate the interpretations of all photometric and spectral data. The Dawn data collected during its approach to Ceres cover phase angles from a few degrees to ~155º, and almost cover the full range of incidence angles and emission angles from 0º to 90º, making an excellent dataset for studying the spectrophotometric properties of Ceres. We report the analysis of the photometric properties of Ceres in the visible wavelengths using the Framing Camera (FC) [1] data through all seven color filters and one clear filter, acquired during the approach and the Survey orbit of the mission.

Although previous studies [2-4] suggested a remarkably uniform surface of Ceres, the images collected by Dawn during its approach to the target at a scale of a few km/pixel revealed some small but extremely bright spots and regions, with albedos up to >4 times the average albedo of Ceres, representing the highest contrast so far observed in all asteroids imaged from close distances by spacecraft missions. These bright spots should be geologically young, and might be related to the episodic water sublimation activity of Ceres [5-7]. We performed detailed comparisons of the albedos of these bright spots between previous Hubble Space Telescope (HST) observations and the Dawn observations that span about 10 years to search for any possible changes.

By the time of preparing this abstract, the Dawn FC has collected images at pixel scale down to 2.1 km/pixel. By June 2015, the data with a scale of 0.4 km/pixel will have been collected during the Survey Orbit phase.

## 2. Initial Results

We modeled the photometric data with both disk-integrated analysis and disk-resolved modeling, with the empirical models such as the IAU HG model [8] and the more recent H, $G_1$, $G_2$ model and H, $G_{12}$ model [9], and Hapke models [10]. The disk-integrated phase function of Ceres derived from the approach images, together with some models, are shown in Fig. 1. No data within the opposition surge are available, and therefore the opposition parameters are not constrained by Dawn data, but assumed from previous studies [11]. The Hapke roughness parameter, $\theta$, is preliminarily constrained by the disk-resolved images at 45º phase angle to be 21º. We expect to refine the analysis in all color filters in the visible wavelengths from 0.45 μm to 0.98 μm using the Survey orbit data.

The comparisons between the albedo measurements of bright spots in HST images and Dawn FC images are strongly affected by the distinctly different characteristics of the two instruments. The point-spread-function (PSF) of HST/ACS/HRC that was used to image Ceres in 2003/04 [2] has 80% of its energy encircled at 5 pixels radius. The same occurs for FC at 0.7 pixels [12]. Given that the size of many features is a few km across, smaller than the pixel scale in the HST images, Dawn images need to be convolved with the HST PSF and downsampled to comparable pixel size for a reliable comparison. The albedos of some of the most prominent bright spots

are shown to be consistent with previous HST measurements. We will use the high-resolution images collected during the Rotational Characterization 3 at a pixel scale of 1.4 km/pixel to refine these results, and also compare the color of Ceres' surface with the previous measurements from HST data.

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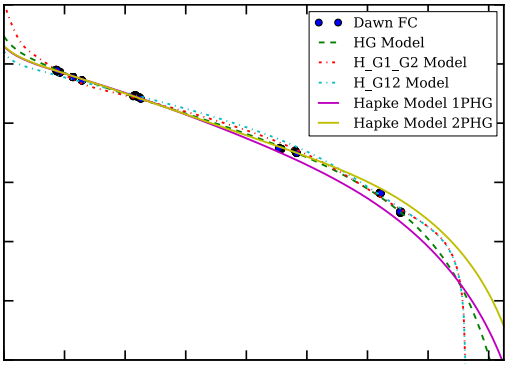


Fig. 1. The best-fit disk-integrated photometric models of Ceres with the approach data. The model parameters are: IAU HG: $H$=3.06, $G$=-0.015; IAU H, $G_1$, $G_2$: $H$=1.73, $G_1$=0.046, $G_2$=0.069; IAU H, $G_{12}$: $H$=3.55, $G_{12}$=0.23; Hapke model with 1-parameter Henyey-Greenstein (HG) single particle phase function: $w$=0.098, $g$=-0.31; Hapke 2-parameter HG function: $w$=0.12, $b$=0.35, $c$=0.38. $B_0$=1.06, $h$=0.06, and $\theta$=21º are fixed for both Hapke models