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Spatially resolved photometric Maps of Asteroid 1 Ceres

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Observations of asteroid 1 Ceres obtained with Hubble Space Telescope's (HST) High Resolution Channel of the Advanced Camera for Surveys (HRC/ACS) were acquired in December, 2003 and January 2004 covering more than one rotation of Ceres through three filters at 220, 330 and 555 nm, at a phase angle of 6.2 degrees. The pixel scale of $\sim$30 km corresponds to about 3.5 degrees longitude/latitude at Ceres' equator. The measured brightness is converted to absolute magnitude at 1 AU heliocentric and geocentric distance. A solar spectrum modulated by the instrument's filter thoughputs is used to determine the reflectance, I/F at each wavelength. The resulting lightcurves are compared with ground-based observations at similar phase angles and agree both in shape and amplitude. With the recently calculated shape and pole orientation of Ceres from the same data (1), it is apparent that the 0.04 magnitude amplitude of the light curve is due to albedo patterns on the surface. Combining these observations with earlier ones [2,3], the spectrum of Ceres at UV-visible is characterized by an absorption band centered at about 280 nm, with the width of about 100 nm, and about 30% of the reflectance at 555 nm. This absorption feature could be due to a charge transfer or a semi-conductor band, and is present in the spectra of many iron-bearing minerals and salts. However, it cannot be matched by any available laboratory measured UV spectra. With disk-resolved images of Ceres and its shape, limb-darkening characteristics of Ceres are modeled. Combining parameters derived from ground-based observations (Bo =1.6, h=0.06, g=-0.40) [4] with disk-resolved data and Hapke's theory [5], resulted in a good fit for the central portion of the asteroid only. The single-scattering

albedo at V-band is 7%, yielding a geometric albedo of 9%, in agreement with earlier measurements [6]. The roughness of Ceres is unusually high, and not consistent with the results measured from the ground [4], but consistent with what is inferred by IR observations [7]. Radar observations also indicate a surface that is very rough at scales larger than meters or tens of meters but very smooth at centimeter to decimeter scales [8]. Therefore, if the high roughness is real, the surface of Ceres must be made of very smooth materials, either like the surface of ice or deposited by very fine grained particles, but saturated with craters at the sizes of tens of meters to kilometers, even while it is globally relaxed. Since the total reflectance of dark surfaces like Ceres is proportional to SSA, the ratio of HST images and their corresponding model from disk-averaged limb darkening models yields the SSA map of Ceres' surface. By combining all HST images covering the whole surface of Ceres, global SSA maps for low latitude area on Ceres are presented that can be photometrically modeled. The distribution of the SSA of Ceres at three wavelengths all show a unimodal shape with very narrow ranges (3%). The upper limit of color variation determined from the SSA variations should not exceed 5%. The SSA and color variations of Ceres are much smaller than those of other asteroids that contain no water, but very similar to those of the icy moons of giant planets. Ceres has the most uniform surface of solar system small bodies measured to date. This is probably related to the possible resurfacing process involving water, and consistent with the most recent evolution model of Ceres [9]. Eleven albedo features are determined to be statistically significant, usually in three filters. The features can be divided into two color groups. These results suggest that Ceres' has been resurfaced since its formation. The Dawn mission will provide more detail to understand these results with both increased spatial resolution, spectral measurements in the UV-Vis and IR, and neutron and gamma-ray spectra to test the suspicion that water has played a role in surface processing of Ceres.

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