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Active regions on 1 Ceres in Dawn Framing Camera colours

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Abstract

Very prominent bright sites on the dwarf planet Ceres were imaged by the Dawn Framing Cameras. Continuing analysis during early phases of this mission revealed their unique visual and near-infrared spectral properties. These, their local diurnal variability, and their geologic context hint at an unprecedented phenomenon among planetary bodies.

1. Introduction

Dwarf planet Ceres is located near the H_2O „snow-line“ of the Solar System, inside of which the sublimation of water ice becomes sufficiently strong that water ice cannot be stable for a long time when exposed on the surface. Indications for water vapour were first reported by A'Hearn et al. (1992) [1], and more recently Küppers et al. (2014) [2] have reported water absorption based on data obtained by the Herschel observatory. This last is suggesting possible surface or shallow subsurface water ice or cryovolcanism. The Dawn spacecraft [3] reached Ceres in March, 2015, and has imaged its surface [4, 5] with the on-board Framing Cameras [6] during approach and high orbits dedicated to scientific imaging.

2. Bright spots

While some modest albedo variations on Ceres have already been reported from HST images [7], bright spots were already outstanding in Dawn FC images during the early approach phase. Besides one site with prominent sources of this enhanced signal, several similar but smaller features have been found (Fig. 1). The most prominent are located in small depressions inside moderately large craters (>60 km in diameter), but some may not be associated with impact features. The context of the bright spots is a surface characterized by viscous relaxation, collapsed crater centres and related linear tectonic features.

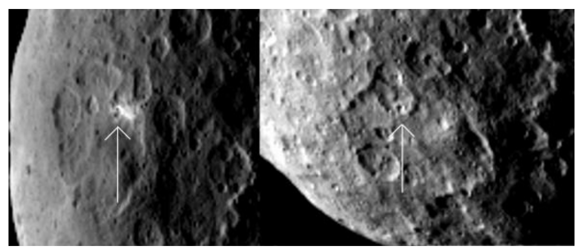

Figure 1: Diurnal change of brightness at a pit in a complex crater. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

In FC colour filter images the bright spots show not only enhanced reflectance, but also a significantly different spectral shape between 440 nm and 960 nm, which could be consistent with water ice. Mixtures with other components cannot be ruled out.
The albedo and heliocentric distance of Ceres enable maximum surface temperatures a few tens degrees below 0° Celsius. Inside this distance water sublimation on comets increases significantly from their dark surfaces. Ceres may have reservoirs of liquid water or ice overlain by an ice-rich crust [8, 9]. Impacts or tectonic processes may lead to local exposure of such material.
A comparison of images of the same features at different rotational phases, and consequently different insolation, even in broad band “clear filter” images, show large changes in reflectance in and near the cores of the bright spots. Their maximum signal is reached near local noon, and close to the terminator no contrast to the surrounding material remains visible. Also in spectral distribution some variability is detectable depending on the amount and geometry of insolation.

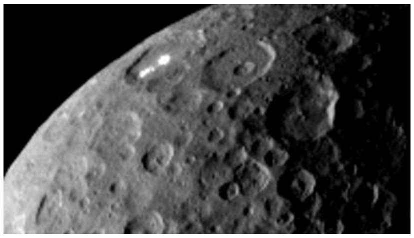

Figure 2: Details of the brightest feature on Ceres. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

A multi-component structure of the feature in Fig. 2 is indicated consisting of: A primary and possible minor companion, potential deposits, and a superposed extended area, which appears to change its orientation during the progressing day-time.

The crater of the brightest feature has a dark halo extending 200 km to the north-east of its host crater. Since similar and even larger dark areas are associated with some major craters without bright spots, it suggests that they are consequences of the context of the bright spot phenomenon. Since it is improbable that the bright spots have been present over the course of Ceres' history, and other similar features may have been present in the past on Ceres, these dark areas may be remnants or tracers of former similar phenomena and processes. Some smaller craters show spectra at central peaks with a trend towards the brighter, negative-sloped areas surrounding the spots.

3. Summary and Conclusions

Spectral properties and diurnal variability are consistent with insolation-dependent local activity on the surface of Ceres. While cryo-volcanism and impact-generated hydrothermal processes are possible alternatives explaining this activity, the current observational evidence by low-resolution imaging and visual-NIR spectral data rather favour local sublimation. No centres of activity have been detected near linear morphologic features yet. Temperatures at Ceres are sufficient to trigger sublimation of exposed ice layers at its heliocentric distance [10]. The possibility of sublimating areas is further supported by the morphology of impact features and current models of Ceres' interior and geologic history, as collapsed central peaks in some craters and other indications of a weak crust suggest.

References

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