EPSC Abstracts
Vol. 10, EPSC2015-65, 2015
European Planetary Science Congress 2015

The preliminary shape of Ceres

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Abstract

Methods have been developed [1, 2] to derive the global shape of an asteroid quickly with the help of limb images taken by spacecraft. Topographic profiles are found by applying a contrast-based search along the limb. By minimizing height differences at crossover locations between the individual limb profiles their locations are improved and a global network is created. We used images taken by the Dawn spacecraft during the Ceres approach in February of 2015 to derive the shape of the asteroid. 87 images from the RC1, RC2, OPNAV 4, OPNAV 6, and OPNAV 7 phases have been examined yielding a network of topographic profiles spanning from ca. 78°S to 83°N. By fitting a tri-axial ellipsoid to the data we found Ceres to be an oblate spheroid with axes significantly smaller than previously estimated [3].

1. Introduction

Several methods can be used to determine the global shape of celestial bodies, e.g. laser altimetry, stereo-photogrammetry, and stereo-photoclinometry. Another well-known procedure is the analysis of limb images [4].

2. Image data

We used 87 Dawn FC limb images from the RC1, RC2, OPNAV 4, OPNAV 6, and OPNAV 7 mission phases from February to April of 2015 (Table 1) in a combined analysis. RC1 and RC2 provide data from full rotational periods while the OPNAV limb profiles cover areas between 270°E and 120°E. The whole set of profiles spans from ca. 78°S to 83°N offering an almost global coverage of Ceres' surface (Fig. 1). To avoid bias towards the comparably dense OPNAV data, only selected profiles of these are included in the analysis ensuring a more or less uniformly built network.

Mission phase	Image count	Distance [km]	Resolution [km/px]
RC1	39	83,000	7.6 – 7.8
RC2	36	46,000	4.3
OPNAV 4	5	40,000	3.8
OPNAV 6	4	34,000	3.1
OPNAV 7	3	23,000	2.1

Table 1: Image data overview

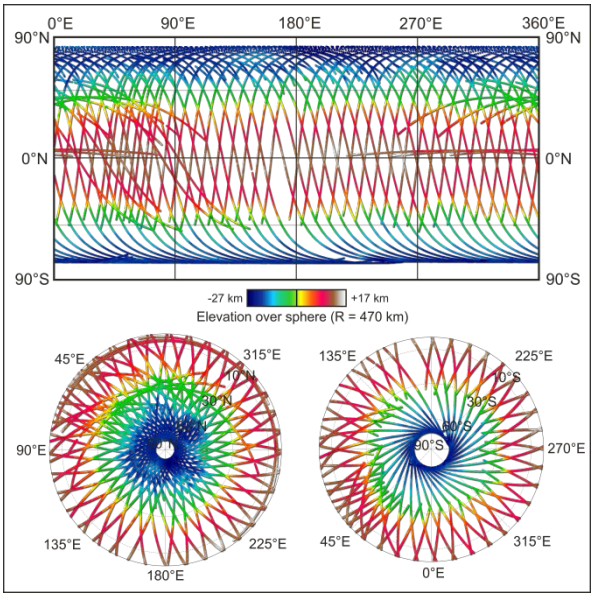

Figure 1: Ceres limb profiles in global equidistant projection (top) and in Lambert azimuthal projection for both hemispheres (bottom)

3. Method

Topographic profiles are found by applying a contrast-based search along the limb. Their locations on a reference sphere are improved by adjusting the exterior camera orientation parameters, i.e. attitude angles, for each limb image using height differences at intersections between the profiles in a least-squares-fit. The selected profiles provide almost 1,700 intersections, with the vast majority residing in the higher northern latitudes.

4. Results

We have fitted a tri-axial ellipsoid with axes of a = 481.0 ± 0.6 km, b = 479.8 ± 0.6, and c = 446.3 ± 0.4 km to the ca. 47,000 object points. The difference between the semi-major axes a and b is within error margins, therefore, Ceres can be described as an oblate spheroid with a significant polar flattening of f = 1/14. The resolution of the network is good enough to resolve large-scale (> 100 km) topographic features, e.g. large basins (Fig. 2).

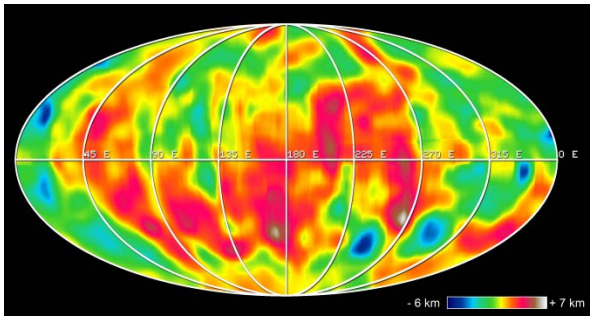

Figure 2: Interpolated digital terrain model in Mollweide projection. Heights are over a biaxial ellipsoid (a = 480 km, c = 446 km).

5. Summary and Outlook

We have derived the shape of Ceres from Dawn FC limb images. Ceres is an oblate spheroid with a significant polar flattening. Large-scale topography is visible in the limb profiles.
The introduction of additional observations from subsequent mission phases will help to further stabilize the network and refine the results. Images with higher resolutions will enable us to identify and measure topographic features at the limb.

References

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