EPSC Abstracts
Vol. 10, EPSC2015-407, 2015
European Planetary Science Congress 2015

Gravity Science Investigation of Ceres from Dawn

R.S. Park (1), A.S. Konopliv (1), C.A. Raymond (1), S.W. Asmar (1), B. Bills (1), C.T. Russell (2), D.E. Smith (3), and M.T. Zuber (3)
(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, (2) UCLA, Los Angeles, CA, USA, (3) Massachusetts Institute of Technology, Cambridge, MA, USA

Abstract

The Dawn gravity science investigation utilizes the DSN radiometric tracking of the spacecraft and landmark tracking from framing camera images to determine the gravity field and orientation parameters of Ceres [1,2]. The gravity science data was collected since the Dawn spacecraft entered an orbit around Ceres on March 6, 2015, and currently, a preliminary solution is available.

1. Introduction

The Dawn spacecraft acquired DSN radiometric data at X-band (8.4 GHz) since it entered an orbit around Ceres. The DSN range data typically provides ~2 m accuracy and is mainly used to determine the ephemeris of Ceres. The DSN Doppler data typically provides ~0.2 mm/s accuracy at 60s count time and is mainly used to determine the spacecraft ephemeris, gravity field, and orientation parameters of Ceres. Through an image correlation process of onboard framing camera data, a 3-dimensional shape of Ceres is created. The landmark tracking data is reduced from a global shape reconstruction process [3], which provides an additional constraint on Ceres-relative position of the Dawn spacecraft. Based on the Approach phase data, we have: GM (km^3/s^2) = 62.7±0.1, Pole R.A. (deg) = 291.8±0.1, and Pole Dec. (deg) = 67.1±0.1.

The Dawn spacecraft currently maintains its attitude by using its two remaining reactions wheels and hydrazine-powered jets. Considering this additional non-gravitational perturbation, we expected to determine the gravity field of Ceres to about degree and order 5 (see Figure 1).

Once the final gravity field is determined, it can be correlated with the gravity derived from a shape model with various interior models to provide constraints on its internal structure. For example, Figure 2 shows the radial acceleration of Ceres based on the constant-density shape model of [4]. Also, the offset between the center-of-mass and the center-of-figure can be computed for a first-order test on homogeneity, and second-degree harmonics can be used to test hydrostatic equilibrium of Ceres. Deviations from the constant density shape model at higher orders will be compared to the surface morphology to understand the subsurface structure, including impact basins.

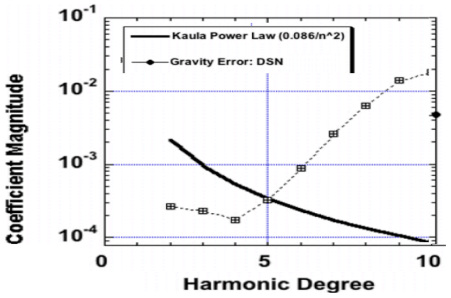

Figure 1: Expected error spectrum of Ceres gravity field at the end of gravity science investigation where harmonic degree 5 gives 300 km resolution at half-wavelength.

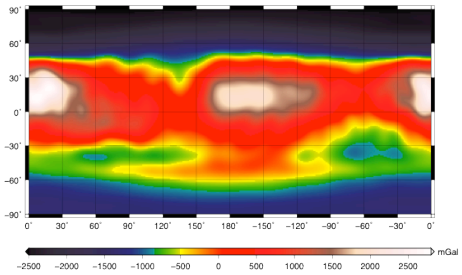

Figure 2: Radial Acceleration (mGal) computed from shape using a 20x20 spherical harmonic expansion and projected onto a sphere with 476 km radius, excluding the point-mass contribution.

Acknowledgements

This work was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

References

[1] Russell, C.T., et al. (2011). *The Dawn Mission to minor planets 4 Vesta and 1 Ceres*. Springer, ISBN: 978-1-4614-4902-7.

[2] Konopliv, A. S., S. W. Asmar, B. G. Bills, N. Mastrodemos, R. S. Park, C. A. Raymond, C. T. Russell, D. E. Smith, M. T. Zuber, "The Dawn Gravity Investigation at Ceres and Ceres," *Space Sci Rev* DOI 10.1007/s11214-011-9794-8 2011.

[3] R.W.Gaskell, "Optical Navigation Near Small Bodies." AAS paper 11-220, AAS/AIAA Space Flight Mechanics Meeting, New Orleans, LA, 2011.

[4] Thomas, P. et al., "Differntiation of the asteroid Ceres as revealed by its shape", *Nature*, 437, 224-226, 2005