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Interior structure of Bennu from OSIRIS-REx data

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Abstract

The initial exploration of asteroid Bennu by the OSIRIS-REx mission [3] has allowed the first detailed assessment of the properties of this asteroid, including its geophysical environment [4]. The small offset [1] between center of mass (COM) and center of figure (COF) indicates moderate interior density heterogeneity, which can be modeled using smooth density gradients [6]. Initial analysis indicates a possible increase in surface density that appears to correlate to the distribution of preserved craters, and this correlation suggests a possible compaction underneath the craters. The measurement of the gravity field of Bennu [5], which is now underway, based on spacecraft tracking and possibly on the reconstruction of the trajectory of long-lived ejected particles [2], will allow us to further constrain its interior. This talk will present the latest results from the mission, using the best estimate of the gravity field available at the time of the conference, to provide limits on the magnitude and distribution of density heterogeneities, and whether they support the cratering compaction hypothesis.

1. Introduction

The gravitational field of asteroid Bennu [5] allows us to explore its internal density distribution, to determine the characteristics of this rubble-pile asteroid. The interior structure can be related to its formation mechanisms and to the internal evolution that led to its current top shape. Radio tracking of the spacecraft represents the standard method for determining the gravity field of an asteroid, and the additional observation of the ejection of particles from the surface of Bennu [2], some of which can be in long-lived orbits, may allow to place additional constraints on the gravity field [5].

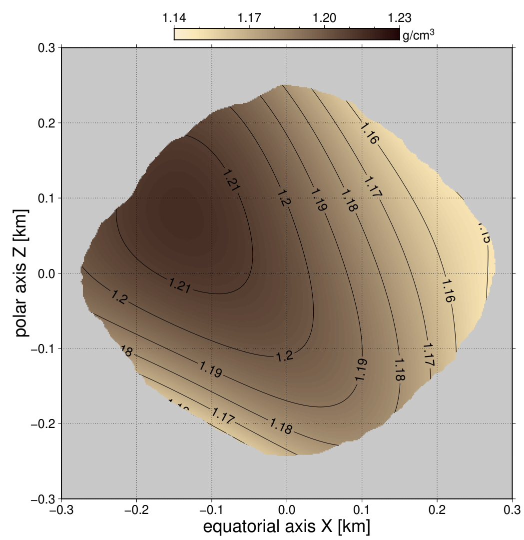

Figure 1: Section of Bennu showing an interior density distribution solution with minimum deviation from uniform density.

2. Global Gravity Inversion

The problem of determining the interior density distribution of a body from its shape and gravity field represents an inverse problem, and admits in general infinitely many non-unique solutions. Many different approaches for its solution have been proposed in the literature, varying principally in their assumptions on the density distribution, and on how solutions are sampled. The Global Gravity Inversion (GGI) method [6] uses smooth density gradients to generate a range of solutions that reproduce the observed gravity field, while accounting for the non-unicity characteristic of gravity inversion problems, as well as the uncertainty in the gravity field [5]. The assumptions on the density distribution can be adapted to each specific body studied. GGI was developed in particular for bodies with arbitrary shape, although it can be applied as well to large bodies with a spheroidal shape [7].

3. Initial Results

An initial look at the interior of Bennu can be obtained by applying the GGI approach to the limited set of constraints available: the shape and mass of Bennu, the COM–COF offset, and the direction of the rotation axis. In Figure 1 we show the interior solution with minimum deviation from uniform, displaying a region of higher density close to the surface north of the equator. This solution accounts for the initial set of constraints, and is in good agreement with the published boulder model [4]. The presence of a region with higher density close to the surface could indicate some level of compaction due to cratering, and while initial results appear to suggest this possibility, we will need a further analysis of the crater distribution and how this correlates to the surface density distribution in order to support this hypothesis. We expect to present at the conference the full analysis based on the latest estimate of the gravity field of Bennu.

4. Summary and Conclusions

The modeling of the shape and gravity of Bennu allows a first look at the interior of this asteroid, and early results suggest some level of internal heterogeneity, possibly associated to cratering compaction. The conference will provide a first opportunity to look in detail at these results.

Acknowledgements

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