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The Measured Gravity and Global Geophysical Properties of (101955) Bennu

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Introduction: Estimates of asteroid (101955) Bennu's gravity have been determined based on a series of independent solutions from different teams involved on the OSIRIS-REx mission. In addition to classical radio science techniques for estimating a body's gravity field coefficients, the discovery of particles ejected from Bennu that persist in orbit for multiple revolutions provides a unique opportunity to probe the gravity field to higher degree and order than possible by using conventional spacecraft tracking [1]. However, the non-gravitational forces acting on these particles must also be characterized, and their impact on solution accuracy must be assessed, requiring the different gravity field estimates to be compared and reconciled.

Given the measured gravity field of Bennu, rigorous constraints on its internal density heterogeneity can be found by comparing the measured field with the constant density field computed from the asteroid shape. These results in turn provide unique insight into the global geophysical processes that drive the external and internal morphology of small rubble-pile asteroids such as Bennu.

Finally, definitive results on the surface and close-proximity force environment of Bennu can be derived and updated from the initial analysis based on the total mass and constant density shape. Several aspects of the environment are highly sensitive to the gravity field and have changed from earlier results [2, 3, 4].

We will present the current gravity field solutions and uncertainties, update the surface and proximity environment models, and provide the geophysical implications and interpretations of these measurements.

Geophysical Models: The estimated gravity field solutions are compared with the constant density shape model to constrain models of the internal density variation. We find that these differences are consistent with Bennu having an under-dense core and equatorial ridge. The degree to which these are under-dense cannot be specifically constrained, but feasible ranges for these values can be determined.

An under-dense equator could be consistent with transport of material to the equator without compaction. Given the slope transition at the Roche lobe, this would also be consistent with the ballistic transport of material into the equatorial region. Estimates of the rate of particle migration do not seem to be enough to account for the overall equatorial bulge of Bennu, however, implying that this feature could be older and not due to the more recent transport of material to the equator.

The lower-density interior is consistent with a period of rapid spin and failure of the interior of the body [5]. This could also be consistent with the raised equatorial bulge. This interior failure could have occurred in an earlier epoch of YORP-induced rapid rotation or could trace to the initial formation of Bennu as a distinct rubble-pile body [6]. Tests of this hypothesis require additional simulations of how rubble-pile asteroids coalesce after the catastrophic disruption of their parent body.

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