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

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Introduction: Current 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 are expected to change from earlier results [2, 3, 4].

We assess 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: Using the determined density inhomogeneity patterns, we investigate specific geophysical aspects of Bennu. Current estimates show the measured *J2* and *J4* gravity coefficients to be larger than the constant density values. If these trends stay consistent with the final gravity field estimates, it points to a combination of an over-dense equator and under-dense center. The evaluation of the other gravity field coefficients will constrain the degree to which the interior density is inhomogeneous, applying the simple theory outlined in [5].

An over-dense equator could be consistent with transport of material to the equator which is subsequently compacted. This would match with the lower slope region within the rotational Roche lobe. If this is paired with a lower-density interior, then it could be consistent with a long-ago period of rapid spin and failure of the interior of the body along with preferential transport of material to the equator.

An alternate hypothesis holds that the asteroid took on its shape when it was initially formed and has not shifted since [6]. This theory is consistent with a stronger rubble pile that has not changed its shape or rearranged material over many YORP cycles. 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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