

**DDA 36th Meeting, 10-14 April 2005**  
*Session 4 Dynamics of Rotating Bodies*  
*Oral, Monday, April 11, 2005, 3:05-5:25pm*

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## **[4.02] Abrupt Alteration of Asteroid 2004 MN4's Spin State During its 2029 Earth Flyby**

*D.J. Scheeres (Univ. of Michigan), L.A.M. Benner, S.J. Ostro (JPL/Caltech), A. Rossi (ISTI-CNR, Italy), F. Marzari (Univ. of Padova), P. Washabaugh (Univ. of Michigan)*

The ~0.4 kilometer diameter asteroid 2004 MN4 will pass  $36700 \pm 9000$  km ( $5.7 \pm 1.4$  Earth radii) from Earth's center on April 13, 2029. We explored the parameter space of possible spin-state changes by conducting Monte Carlo simulations that model the asteroid as a tri-axial ellipsoid with length-to-width ratio 1.4, rotating uniformly about its shortest axis with a period of 24 h. Our results suggest that the overwhelmingly likely outcome of the flyby will be NPA rotation of the asteroid with a distinctly different effective spin period. Precision solution of the equations of motion establish that the post-flyby spin period could be as short as 15 or as long as 45 hours. Spin state changes will alter the Yarkovsky acceleration and thus the asteroid's future close approaches. The spin-state alteration occurs almost entirely during a one-hour interval centered on the closest-approach epoch. Ground-based radar observations using current systems at Goldstone and Arecibo would be able to determine the pre- and post-flyby spin states via daily sequences of decameter-resolution imaging from early April to mid May.

If the asteroid's density is greater than  $\sim 1$  g cm<sup>-3</sup> it will remain outside of the classical Roche limit, while for densities less than this some portion of the closest approach uncertainty ellipse lies within the asteroid's Roche limit; at a density of 0.44 g cm<sup>-3</sup> the nominal flyby distance is at this limit. Terrestrial torques will cause angular accelerations as strong as  $10^{-8}$  rad/s<sup>2</sup> (7.5 deg/hr<sup>2</sup>), and particles on the surface will experience fractional changes in local gravity as large as 0.1 for an asteroid density as large as 2 g cm<sup>-3</sup>. If 2004 MN4 has a low density and is a gravitationally bound agglomerate, then these angular accelerations could lead to global reshaping or disruption. If the asteroid has a density similar to values estimated for other NEAs it will most likely not undergo catastrophic disruption, however it will be subject to localized failure across its surface and interior. Measurement of structural shifts during the flyby by devices placed on the surface could reveal otherwise inaccessible mechanical properties of the interior.

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