Geophysical Research Abstracts
Vol. 15, EGU2013-5891-1, 2013
EGU General Assembly 2013

Radio frequency occultations show that Mercury is oblate

Mark Perry (1), Daniel Kahan (2), Olivier Barnouin (1), Carolyn Ernst (1), Sean Solomon (3), Maria Zuber (4), David Smith (4), Roger Phillips (5), Steven Hauck (6), Gregory Neumann (7), Stanton Peale (8), Jean-Luc Margot (9), Erwan Mazarico (7), Catherine Johnson (10,11), Robert Gaskell (11), Sami Asmar (2), and Ralph McNutt (1)

(1) Space Department, JHU Applied Physics Laboratory, Columbia, MD 20724, USA (mark.perry@jhuapl.edu), (2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA, (3) Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA, (4) Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA, (5) Planetary Science Directorate, Southwest Research Institute, Boulder, CO 80302, USA, (6) Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH 44106, USA, (7) NASA Goddard Space Flight Center, Greenbelt, MD, USA, (8) Department of Physics, University of California, Santa Barbara, CA 93106, USA, (9) Department of Earth and Space Sciences, University of California, Los Angeles, CA, USA, (10) Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada, (11) Planetary Science Institute, Tucson, AZ 85712, USA

Measurement of the shape of Mercury, particularly when combined with the shape of the geoid, can provide clues to Mercury's internal structure, thermal evolution, and rotational history. The Mercury Laser Altimeter (MLA) provides accurate measurements of Mercury's northern hemisphere and shows that higher latitudes have elevations that are lower than the equatorial regions. Recently analyzed observations of radio frequency (RF) occultations pro-vide approximately 120 southern-hemisphere elevations, and these show a difference between the south-pole radius and the equatorial radius of 2.2 ± 0.1 km that is nearly identical to that observed by MLA for the northern hemi-sphere (2.26 ± 0.05 km). We present the occultation data and discuss possible implications for Mercury's history and interior structure.

The time of occultation is determined by fitting an edge-diffraction curve to the RF power history. The positions of MESSENGER, Mercury, and the Deep Space Network antenna provide the radius of Mercury at the point where the RF path grazes a smooth sphere centered at Mercury's center of mass. We use digital terrain models (DTMs) derived from stereo photoclinometry to identify the local occulting edge and adjust the raw occultation radius to produce the final result, the average elevation in the region surrounding the occultation edge.

The current flattening, if a preserved hydrostatic shape, corresponds to a rotation rate of 100 to 200 h, depending on the degree of relaxation as rotation slowed. Both the formation and thickening of Mercury's lithosphere and despinning from an initial rapid rate such as a 10-h rotation period were likely complete before the end of late heavy bombardment. The timescales for despinning and lithospheric thickening are comparable, but the former may be too dependent on stochastic events to establish a relationship.

Mercury's geoid is a factor of 10 less oblate than Mercury's shape. This difference requires compensation on a global scale. If the compensation is confined to variations in crustal thickness, then a mantle/crust density ratio of 1.1 implies that pole-to-equator crustal thickness variations of 22 km are required to maintain the 2.4 km difference in polar and equatorial radii. The northern hemisphere crustal thickness indeed displays a thinning toward the pole. However, models of mantle convection predict smaller-scale structure than would be consistent with either the hem-ispheric-scale crustal thickness pattern or the oblateness. Understanding the relationship between geophysical and geological observations and geodynamical evolution will be a high priority for further study.