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Mercury's interior from MESSENGER geodetic measurements

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The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft completed more than 4 years of operations in orbit about Mercury. One of the main mission goals was the determination of the interior structure of Mercury enabled by geodetic observations of the topography, gravity field, rotation, and tides by the Mercury Laser Altimeter (MLA) and radio science system.

MLA acquired over 25 million individual measurements of Mercury's shape that are mostly limited to the northern hemisphere because of MESSENGER's eccentric orbit. However, the lack of laser altimetry in the southern hemisphere has been partly compensated by $\sim$400 occultations of spacecraft radio signals.

X-band radio tracking data collected by the NASA Deep Space Network (DSN) allowed the determination of Mercury's gravity field to spherical harmonic degree and order 100, the planet's obliquity, and the Love number k_2.

The combination of altimetry and radio measurements provides a powerful tool for the investigation of Mercury's orientation and tides, which enable a better understanding of the interior structure of the planet.

The MLA measurements have been assembled into a digital elevation model (DEM) of the northern hemisphere. We then used individual altimetric measurements from the spacecraft for orbit determination, together with the radio tracking, over a continuous span of time using a batch least-squares filter. All observations were combined to recover directly the gravity field coefficients, obliquity, librations, and tides by minimizing the discrepancies between the computed observables and actual measurements.

We will present the estimated 100×100 gravity field model, the obliquity, the Love number k_2, and, for the first time, the tidal phase lag ϕ and the amplitude of the longitudinal libration from radio and altimetry data. The k_2 phase provides information on Mercury's dissipation and mantle viscosity and allows a determination of the Q factor. A refinement of the longitudinal libration, on the other hand, helps to constrain the ratio of the polar moment of inertia of Mercury's crust and mantle (C_m) to that of the planet (C).