

Measurements of Mercury's Spin State, Moment of Inertia, and Core Size

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Over the past nine years we have used the Green Bank Telescope (GBT) in conjunction with the Goldstone Solar System Radar (GSSR) to characterize the spin state and interior of Mercury. We implemented a technique [1,2] that provides instantaneous spin rate measurements with 10^{-5} fractional precision and spin orientation measurements at the arcsecond level. On the basis of measurements at 21 distinct epochs between 2002 and 2006, we found observational evidence that Mercury closely follows a Cassini state and that it exhibits forced librations in longitude [3], as predicted by theory [4,5]. A long-period (~ 12 year) libration signature may be present in the data.

Since 2006 we have secured measurements at 11 additional epochs (out of 23 attempts). We are re-analyzing the entire set of observations with the goals of (1) refining the determination of the obliquity and of the libration amplitude, two parameters that are critical in the determination of the moment of inertia and core size; (2) confirming the presence or absence of a long-period libration component, with the prospect of elucidating the excitation mechanism; (3) quantifying deviations of the pole from the strict Cassini state, which could inform us about dissipation due to solid-body tides and core-mantle interactions.

Our first goal is particularly important now that MESSENGER has secured measurements of the low-degree gravitational harmonics with a precision of better than 1% [6]. Error budgets indicate that the precision of the estimates of obliquity and libration amplitude will ultimately dictate the quality of the moment of inertia and core size determinations, as well as the attendant inferences regarding the interior structure, thermal evolution, and magnetic field generation of the planet. We will present the most recent estimates of the spin state, moment of inertia, and core size.

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