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Geodesy at Mercury with MESSENGER

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In 2011 the MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) spacecraft will enter Mercury orbit and begin the mapping phase of the mission. As part of its science objectives the MESSENGER mission will determine the shape and gravity field of Mercury. These observations will enable the topography and the crustal thickness to be derived for the planet and will determine the small libration of the planet about its axis, the latter critical to constraining the state of the core. These measurements require very precise positioning of the MESSENGER spacecraft in its eccentric orbit, which has a periapsis altitude as low as 200 km, an apoapsis altitude near 15, 000 km, and a closest approach to the surface varying from latitude 60° to about 70°N. The X-band tracking of MESSENGER and the laser altimetry are the primary data that will be used to measure the planetary shape and gravity field. The laser altimeter, which has an expected range of 1000 to 1200 km, is expected to provide significant data only over the northern hemisphere because of MESSENGER's eccentric orbit. For the southern hemisphere, radio occultation measurements obtained as the spacecraft passes behind the planet as seen from Earth and images obtained with the imaging system will be used to provide the long-wavelength shape of the planet. Gravity, derived from the tracking data, will also have greater resolution in the northern hemisphere, but full global models for both topography and gravity will be obtained at low harmonic order and degree. The limiting factor for both gravity and topography is expected to be knowledge of the spacecraft location. Present estimations are that in a combined tracking, altimetry, and occultation solution the spacecraft position uncertainty is likely to be of order 10 m. This accuracy should be adequate for establishing an initial geodetic coordinate system for Mercury that will enable positioning of imaged features on the surface, determination of the planet's obliquity, and detection of the librational motion of the planet about its axis.