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Mercury's gravity field, orientation, and ephemeris after MESSENGER's Low-Altitude Campaign

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In April 2015, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft will complete more than 4 years of operations in orbit around Mercury. In its last year, as part of MESSENGER's Second Extended Mission (XM2) started in March 2013, the spacecraft has been collecting radio tracking data at unprecedented low altitudes in Mercury's northern hemisphere. During the first two years in orbit, the spacecraft periapsis altitude was kept between 200 and 500 km, while its location drifted slowly northward from 60˚N to 84˚N. The orbital period initially was 12 h, but it was decreased to 8 h in April 2012.

The remaining fuel onboard the spacecraft enabled two extended missions, the last of which will end with an impact expected on or before 28 April 2015. During the second extended mission, the periapsis altitude has been as low as 15-25 km. NASA's Deep Space Network (DSN) tracked the spacecraft during periapsis passages from April to October 2014, when the spacecraft periapsis altitude was between 25 and 100 km. In the last six months of the mission, the closest approaches of MESSENGER were occulted by Mercury and were thus not visible from Earth. However, additional radio tracking data have been collected at altitudes (75–100 km) that are still substantially below the initial periapsis altitude.

The new low-altitude radio tracking data have enabled an updated model of the gravity field of Mercury. With these data, the resolution of the field in the northern hemisphere has been improved, revealing features that were previously undetectable and that correlate well with topography. The zonal harmonics are in good agreement with those in previous models of the gravity field. We also focused our study on the determination of other geophysical parameters, such as the orientation of Mercury. The new data were acquired not only at lower altitudes but also at latitudes closer to the equator, so they provide important information on tides, the right ascension of the pole, and the physical libration in longitude.

The new model of Mercury's gravity field includes the estimation of the declination and the right ascension of the pole, the Love number k2, and the amplitude of the longitudinal libration. We also report an update on the ephemeris of Mercury obtained from MESSENGER range data covering the entire mission period, from the flybys until the end of the mission.