Geophysical Research Abstracts
Vol. 20, EGU2018-15609, 2018
EGU General Assembly 2018

Mercury Interior with MESSENGER Radio Science Investigation

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Dedicated magnetic and gravity investigations enabled the Mercury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission to address key scientific objectives related to the internal structure of the planet. However, questions concerning the nature of Mercury's core are still open.

To determine the mass distribution within the different layers of the deep interior, we estimated the right ascension and declination of the pole by measuring the gravity field of Mercury with the full MESSENGER mission dataset, which includes the low-altitude campaign. We processed the radio tracking data with a novel technique that is based on the co-integration and co-estimation of both MESSENGER and Mercury orbits. Our solution results in improved accuracies of gravity anomalies and spin axis coordinates. The orientation of Mercury's pole is directly linked to the polar moment of inertia of the planet that provides crucial information on its level of differentiation.

Our latest solution of the normalized polar moment of inertia, c, suggests a much more differentiated planet compared to previous studies. We used this geophysical constraint to retrieve Mercury's interior structure by implementing a Markov-chain Monte Carlo (MCMC) algorithm. Two approaches were applied to obtain solutions that match Mercury's bulk density and radius, and the estimated c and the fractional polar moment of inertia C_{c+m}/C. First, we considered a 5-layer planet (inner core, two layers for the outer core, mantle and crust), with the only assumption that the density increases with depth. The second approach is also based on a 5-layer interior, but it uses 1-km sub-layers for the integration of the Equation of State (EoS).

The resulting internal models of both methods provide evidence of the presence of a large solid inner core with a radius (r_{ic}) that is between 30% and 60% of the radius of the outer core (r_{oc}). Furthermore, our simulations of Mercury's magnetic field dynamo suggest that the presence of a solid inner core with a $r_{ic} \leq 0.5\ r_{oc}$is consistent with the magnetic field enabling us to constrain even further the properties of the core.