A Large Solid Inner Core at Mercury. A. Genova[1,2], S. Goossens[2,3], E. Mazarico[3], F. G. Lemoine[3], G. A. Neumann[3], W. Kuang[3], T. J. Sabaka[3], D. E. Smith[1] and M. T. Zuber[1], [1]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139-4307, USA (antonio.genova@nasa.gov); [2]Center for Research and Exploration in Space Science and Technology, University of Maryland, Baltimore County, Baltimore, MD 21250, USA; [3]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.

Introduction: The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission addressed key scientific objectives focused on the interior of the planet with dedicated magnetic and gravity investigations. The measurement of the magnetic field offset and amplitude, for example, allowed the characterization of some properties of the outer core [1]. In addition, the combination of the planet's orientation (obliquity -- angle between spin and orbital axis -- and physical longitudinal librations) with gravity measurements (degree 2 in spherical harmonics) have constrained the size of the molten outer core [2, 3].

However, there are still open questions concerning the mass distribution within the different layers of the planet interior and, in particular, nature and size of the solid inner core. The analysis of the entire MESSENGER radio science dataset, which includes the low-altitude campaign, enabled us to substantially improve the knowledge of Mercury's gravity field and obliquity of the spin axis. These geophysical quantities are necessary to refine the polar moment of inertia of the whole planet which bears on the level of differentiation [4].

Data and Method: Our new gravity solution provides refined estimates of the spin axis coordinates (right ascension and declination) that permits the retrieval, for the first time, of the average obliquity of the *whole* planet, which we find in perfect agreement with the Cassini state.

The normalized polar moment of inertia, C/MR^2, resulting from the new obliquity is significantly lower than the previous estimate of 0.346±0.011 [5] and with an uncertainty improved by a factor of 3 [6]. Our refined estimate of the polar moment of inertia suggests that Mercury is much more differentiated than initially thought.

We implemented a Markov-chain Monte Carlo (MCMC) algorithm to obtain solutions that match bulk density and radius and our latest estimates of the normalized polar moment of inertia, C/MR^2, and the fractional polar moment of inertia, C_{cr+m}/C.

Results: We integrate the governing differential equations for pressure and density under hydrostatic equilibrium (using 1 km thick layers) to retrieve models that are self-consistent and physically realistic in terms of their pressure, temperature and density profiles [7]. However, this approach requires an initial assumption on the light element that is present in the core. A possible scenario is an inner and outer core of Fe-Si alloy. Figure 1 shows the ratio between inner core (r_{ic}) and outer core radii (r_{oc}) as a histogram for the Multi-layer ensemble. These results suggest the presence of a solid inner core with a $r_{ic} \approx$ 0.3-0.7 r_{oc}.

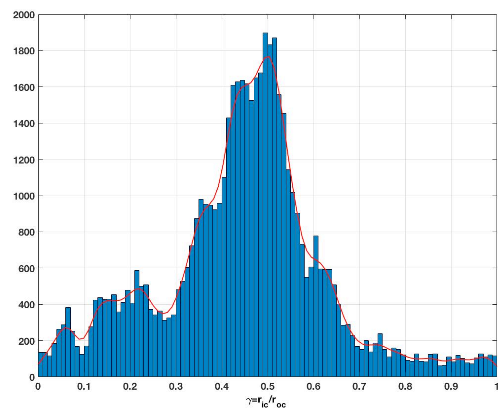

Figure 1. Ratio between the inner and outer core radii as a histogram for the samples of the Multi-layer MCMC solutions.

Summary: Our new measurements of the polar moments of inertia of the whole planet and of the outer layers (crust+mantle) suggest a more differentiated internal structure for Mercury. These geophysical quantities improve the constraint on the size of the solid inner core. Furthermore, simulations of Mercury's magnetic field dynamo confirm that the presence of a solid inner core with a $r_{ic} \leq 0.5\ r_{oc}$ is consistent with a magnetic field, thus providing an additional constraint on the size of the solid inner core.

References: [1] Anderson B. J. et al. (2012) *J. Geophys. Res.* 117, E00L12. [2] Margot J. L. et al. (2007) *Science* 316, 710-714. [3] Margot J. L. et al. (2012) *J. Geophys. Res.* 117, E00L09. [4] Peale S. J. et al. (2002) *Meteorit. Planet. Sci.* 37, 1269-1283. [5] Stark A. et al. (2015) *Geophys. Res. Lett.* 42, 7881-7889. [6] Genova A. et al. (2018) *In prep.* [7] Hauck S. A. II et al. (2013) *J. Geophys. Res.* 118, 1204-1220.