EPSC Abstracts
Vol. 13, EPSC-DPS2019-1223-2, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Core radius uncertainty of Mars inferred from nutation estimation for non-hydrostatic interior models

Marie Yseboodt[1], Attilio Rivoldini[1], Sébastien Le Maistre[1], Véronique Dehant[1 2]
[1] Royal Observatory of Belgium, Brussels, Belgium (m.yseboodt@oma.be),
[2] Université catholique de Louvain, Earth and Life Institute, Louvain-la-Neuve, Belgium

1. Nutation for a planet with a liquid core

Nutations are the oscillations of the spin axis direction in space. They are due to the solar torque acting on a flattened Mars and to Phobos and Deimos torques. Their periods in an inertial frame are mostly the Martian annual period and its harmonics (semi-annual, ter-annual,...).
Nutations for a rigid Mars can be accurately computed from planetary ephemerides using the torque approach (see EPSC2019 abstract "Rigid nutations of Mars" by Rose-Marie Baland et al).

The **liquid core** inside Mars affects its nutation amplitudes: nutation amplitudes can be **resonantly amplified** because of the existence of a rotation mode, the Free Core Nutation (FCN). Present day core size estimates suggest that the retrograde ter-annual r_3 nutation (-229 days) can be resonantly amplified by the presence of a liquid core. The other most affected nutations are p_2 (the prograde semi-annual), p_3 (the prograde ter-annual) and r_1 (the retrograde annual).
The amplification can be of a few milliarcseconds (mas), corresponding to a few centimeters on Mars surface. This amplification can even be larger if the FCN period is very close to one of the main nutation periods.

2. Interior models and prior functions

We use a large set of plausible **interior structure models** of Mars with five mantle mineralogies and a hot and a cold mantle temperature end-members deduced from thermal evolution studies. The **core** is assumed to have a **non-hydrostatic shape**. This non-hydrostaticity shape of the core increases the FCN period by about 10% if compared to a hydrostatic shaped core. The effect of the internal structure for these interior models and core shape on nutations are discussed in the EPSC2019 abstract "Non-hydrostatic effects on Mars'nutation" of Attilio Rivoldini et al.
These nutation amplifications as a function of the liquid core size are our prior functions.

3. Method

We assume the nutation amplifications p_2, r_1, r_3 and p_3 are estimated with an uncertainty of a few mas provided by an extensive set of geodesy measurements.
Such nutation amplitudes estimations will be available soon thanks to the RISE radio science experiment measurements onboard the InSight mission presently on Mars and thanks to the LaRa experiment onboard the ExoMars2020 mission (landing in 2021).
We solve the inverse problem using a Bayesian inversion method assuming a given precision on the synthetic nutation amplifications.
The objective is to estimate the precision that can be obtained on the core radius combining the information coming from different nutations.

References

- Dehant, V. et al., 2019, "LaRa (Lander Radioscience) on the ExoMars 2020 Surface Platform", EPSC2019 abstract.
- Folkner, W., Kahn, R., Preston, R., Yoder, C., Standish, E., Williams, J., Edwards, C., Hellings, R., Eubanks, T., Bills, B., 1997. Mars dynamics from Earth-based tracking of the Mars pathfinder lander. J. Geophys. Res. 102 (E2), 4057-4064.
- Folkner, W. M. and Dehant, V. and Le Maistre, S. and Yseboodt, M. and Rivoldini, A. and Van Hoolst, T. and Asmar, S.W. and Golombek, M. P, 2018, The Rotation and Interior Structure Experiment on the InSight Mission to Mars, Space Science Reviews, Vol. 214.

Acknowledgements

This work was financially supported by the Belgian PRODEX program managed by the European Space Agency in collaboration with the Belgian Federal Science Policy Office.