EPSC Abstracts
Vol. 8, EPSC2013-978, 2013
European Planetary Science Congress 2013

New Mars rotational model from *Opportunity* radio-tracking and implications to the interior structure of Mars.

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1. Introduction

Doppler tracking of the two *Mars Exploration Rovers* considerably extends the time span of available Doppler observations of the Martian surface. The tracking of *Opportunity* (MER1) was conducted during the 2012 Radio Science Campaign, when the rover was hibernating and stationary. Data from *Spirit* (MER2) cover several months in 2009 and 2010 during which the rover was stuck in the sand. The now available data set of Doppler observations, spanning 35 years between *Viking* (1976-78) and *Opportunity* (2012), is especially powerful in terms of constraints on the Mars precession rate. Moreover, the tracking of the Mars Exploration Rovers has been acquired at different epochs in the martian year with respect to the previous X-band tracking of the surface provided by *Mars Pathfinder* (MPF). The now available distribution of X-band tracking data is favorable to the observation of seasonal variations in the martian rotation and orientation such as nutation signatures introduced by a liquid core.

Here we combine all rover and lander data in order to improve the rotational model of Mars (i.e. precession and nutation of the pole of Mars and rotation rate variations). We then seek interior models of Mars that are in agreement with the improved rotation parameters (especially with the precession rate) and with previously measured tides [1]. In addition, we analyze whether the signature of a liquid core can be detected in the nutation data. Numerical simulations are also performed to predict constraints on the interior structure that should be obtained adding one martian year of Doppler data from the InSight 2016-NASA mission [2].

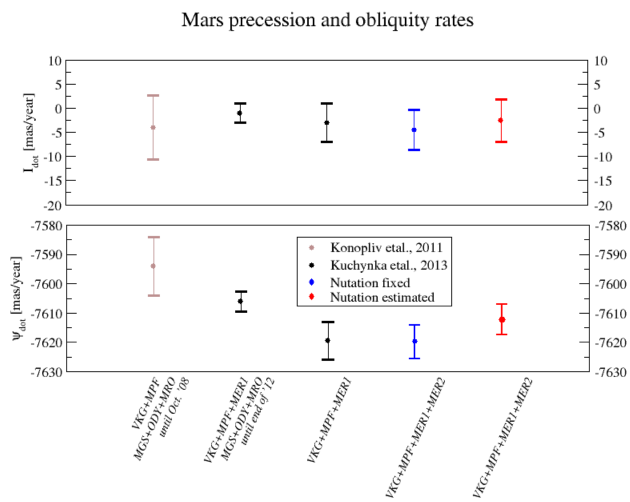

Figure 1: Solutions of Mars Precession and obliquity rates.

2. New constraints on Mars rotation

In order to minimize data processing bias, the different sets of radio-science data have been reduced and analyzed independently by Jet Propulsion Laboratory (JPL) and Royal Observatory of Belgium (ROB). Solutions from JPL were obtained using ODP (Orbit Determination Program) software and solutions from ROB were obtained using the software package "Geodésie par Intégrations Numériques Simultanées (GINS)" developed at the Centre National d'Etudes Spatiales (CNES) and adapted for use in planetary geodesy applications at the ROB.

The rotation parameters estimated in the two approaches are consistent with each other and in particular provide an estimate of -7619±6 mas/y for Mars' pole precession rate if only Doppler data from the surface are used [3]. It appreciably differs from solutions including orbiters data (see Fig. 1).

3. Moment of Inertia and interior structure

By combing the precession rate with gravity field data the polar moment of inertia C of Mars can be calculated. The so estimated value of C is 0.3633±0.0003 using landers-rovers data only (and without nutation estimation). It is significantly smaller and has a reduced uncertainty compared to previous estimate ($C = 0.3644 \pm 0.0005$) [1]. The smaller value of C require that interior structure models of Mars have a somewhat smaller core than models that are in agreement with the previous estimated value of C [4].

4. Nutations and liquid core

The liquid core contribution in nutation is difficult to extract from the available data with a sufficient precision to constraint interior models of Mars. Nevertheless, preliminary results are in favor of a liquid or partially liquid core in agreement with previous results obtained from measured tides [5].

Numerical simulations have shown that the smaller the liquid core radius, the smaller the Free-Core-Nutation (FNC) period [6], and the longer the mission duration have to be in order to precisely estimate the nutation parameters (see fig. 2). Therefore we discuss the detection of the liquid core with additional data from InSight-RISE experiment [2].

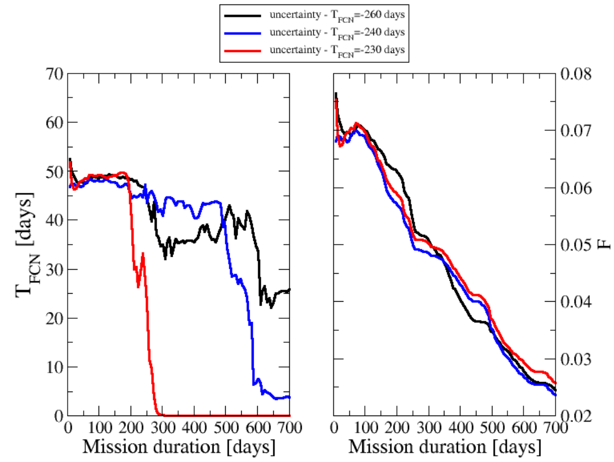

Figure 2: 1-σ uncertainties in FCN period and core momentum factor for three different sizes of the liquid core corresponding to the following three different FCN period: T_{FCN}=-260, -240 and -230 days.

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. This work was in part supported by the Jet Propulsion Laboratory, California Institute of Technology, under contract to NASA. A part of the research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, and supported by an appointment to the NASA Postdoctoral Program, administered by Oak Ridge Associated Universities through a contract with NASA.

References

[1] A. S. Konopliv, S. W. Asmar, W. M. Folkner, Ö. Karatekin, D. C. Nunes, S. E. Smrekar, C. F. Yoder, and M. T. Zuber. Mars high resolution gravity fields from MRO, Mars seasonal gravity, and other dynamical parameters. *Icarus*, 211:401–428, January 2011.

[2] W. M. Folkner, S. W. Asmar, V. Dehant, and R. W. Warwick. The Rotation and Interior Structure Experiment (RISE) for the InSight Mission to Mars. In *Lunar and Planetary Institute Science Conference Abstracts*, volume 43 of *Lunar and Planetary Inst. Technical Report*, page 1721, March 2012.

[3] P. Kuchynka, W. M. Folkner, A. S. Konopliv, R. S. Park, S. Le Maistre, and V. Dehant. New constraints on Mars rotation determined from radiometric tracking of the Opportunity Mars Exploration Rover. *Icarus*, submitted, 2013.

[4] A. Rivoldini, T. Van Hoolst, O. Verhoeven, A. Mocquet, and V. Dehant. Geodesy constraints on the interior structure and composition of Mars. *Icarus*, 213:451–472, June 2011.

[5] C. F. Yoder, A. S. Konopliv, D. N. Yuan, E. M. Standish, and W. M. Folkner. Fluid Core Size of Mars from Detection of the Solar Tide. *Science*, 300:299–303, April 2003.

[6] S. Le Maistre, P. Rosenblatt, A. Rivoldini, V. Dehant, J-C. Marty, and Ö. Karatekin. Lander radio science experiment with a direct link between mars and the earth. *Planetary and Space Science*, 68(1):105 – 122, July 2012.