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Probing the interior structure of Mars by studying its rotation

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Abstract

Studying the rotation of Mars provides knowledge about its interior structure, which is of essential importance to the understanding of its past and present state as well as its future evolution. In particular from rotation, the state of the core can be determined and its composition and size be constrained. Here, we show how nutation measurements can be used to infer knowledge about the interior structure of Mars.

1. Introduction

We study expected improvements in our understanding of the interior structure of Mars from future observations of its rotation. Rotation studies can be used to constrain the interior of Mars by making use of resonances of nutations with normal modes whose frequencies depend sensitively on Mars' interior structure. In particular we study the influence of the interior structure of Mars on the Free Core Nutation (FCN) and Chandler Wobble (CW). The FCN is a relative rotation of the fluid core and the solid mantle when the instantaneous rotation axes of core and mantle do not coincide and the CW is the rotation of the instantaneous rotation axis around the principal moment of inertia axis.

2. Method

We use interior structure models of Mars [3] that are consistent with the most recent estimates of the moment of inertia and tidal Love number k_2 [2]. The models have been constructed from depth-dependent thermoelastic data about mantle minerals and thermoelastic and melting properties of core constituents (iron and sulfur). The models that agree with the geodesy data have cores radii in the range [1607,1945]km and core sulfur concentrations in the range [11,20]wt% at the 3σ level.

For all those models we compute the periods of the FCN and CW and their influence on nutation amplitudes for non-elastic mantle rheology and for hydrostatic and non-hydrostatic flattened planets. We then discuss the obtained results in the light of a future surface lander experiment dedicated to the determination of the rotation of Mars.

3. Results

Fig. [1] represents the period of the FCN as a function of core size. Models with the largest possible cores have FCN periods close to the retrograde $\frac{1}{3}$-annual nutation, which is therefore resonantly amplified (see Fig. [2]).

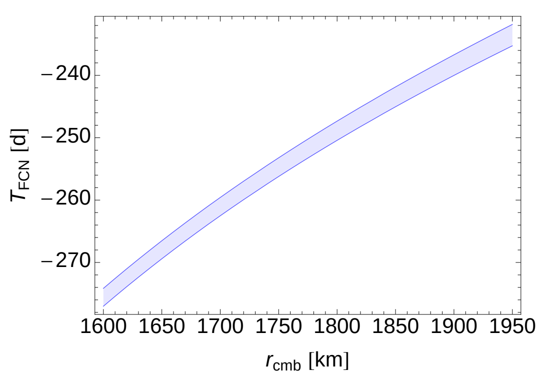

Figure 1: Free core nutation mode period as a function of core size.

With the expected precision of future lander radioscience experiments of a few milliarcseconds, non-rigid amplification of several nutations can be observed and the FCN period be estimated [1]. The precise knowledge of the period of the FCN then allows for a more precise determination of the core size and of its sulfur concentration.

Acknowledgements

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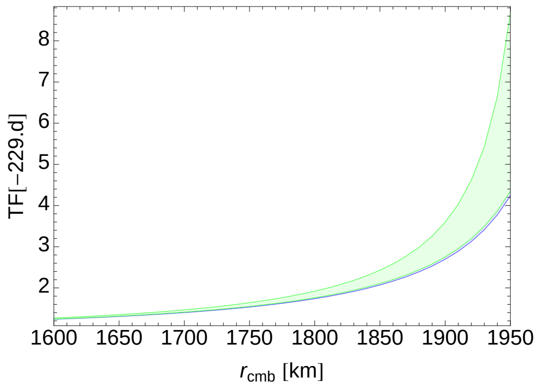

Figure 2: Amplification of the the retrograde $\frac{1}{3}$-annual nutation as a function of core size.

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