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Constraints on the interior structure of Mars from nutations

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Abstract

Studying the rotation of Mars provides knowledge about its interior structure and global scale atmosphere dynamics. In particular, observing Mars' nutation by the forthcoming RISE and LaRa experiments on InSight and ExoMars, allows to infer information about its core. Nutation amplitudes can be resonantly amplified if the planet's core is liquid, thus the state of the core can be determined from the response induced by the precisely known tidal forcing of the Sun acting on Mars. The response to the external forcing does not only depend on the core state but also on its polar moment of inertia, figure, and capacity to deform. By combining measured nutation amplitudes with the already well known polar moment of inertia and tidal Love number k_2 the size of the core and its material properties can be determined more precisely than from the latter quantities alone. Also the polar moment of the mantle can then be determined from which constraints on the mantle's composition and thermal state be obtained.

In this study, we first reconsider the study of the nutations of a rigidly rotating Mars. Next, we use interior structure models of Mars that are consistent with the most recent estimates of the moment of inertia, tidal Love number k_2, and global dissipation in order to model the nutations of the real Mars. The models have been constructed from depth-dependent material properties about mantle minerals and use thermoelastic and melting properties of core constituents (iron and sulfur). For each model we compute nutation amplitudes and then assess the constraints on the interior structure of the core that can be expected by measuring nutations with RISE and LaRa.

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