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Geodetic experiment with ExoMars rover.

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1. Introduction

This paper shows numerical simulations to assess the precision that can be obtained on the determination of the Mars Rotation and orientation Parameters (MOP) by using radio link of ExoMars rover. The primary objective of such a radio-science experiment is a precise measurement of these quantities, which can be theoretically calculated for different states and sizes of the core, for different internal compositions, and for different interior temperature profiles. Precession and length-of-day variations have already been detected from spacecraft data. Precession is presently known at the 0.3% level [1] and length-of-day variations are known at about the 10% level [1]. We already know that a sufficient precision can be reached using Doppler measurements from a lander to improve our knowledge on the MOP and to provide some constraints on its physical parameters [2]. The goal of this paper is to evaluate the impact of different ExoMars mission parameters (frequency band, precision in rover positioning at surface, nature of the radio link (Direct-To-Earth (DTE) or with an orbiter)) in the determination of the MOP. The ExoMars nominal mission duration is very long, 700 days, providing a real opportunity to offset the negative impact of the displacement of the rover at the surface of the planet in this determination.

2. Method of simulations

The experiment proposed is a radio-science experiment on board the ExoMars mission to Mars to be launched in 2018. The variation of Mars' rotation rate (or length-of-day variations), the orientation of Mars' rotation axis in space (precession and nutation), and the orientation of Mars around its rotation axis (polar motion), can theoretically be determined by monitoring the Doppler shift due to the motion of a probe landed on Mars relative to tracking stations on Earth (DTE) and/or relative to spacecraft orbiting Mars. The simulations done here deal with such a radio-science experiment by simulating 2-way (round-trip signal) Doppler measurements. To do so we use the GINS software implemented by the French space agency (CNES) and further developed at Royal Observatory of Belgium (ROB) for planetary geodesy applications.

3. Results of simulations

As closed-loop Guidance, Navigation and Control (GNC) system will most probably permit to position the rover at 10cm of precision relatively to its previous position, this study shows that ExoMars rover mission could bring some improvements on our knowledge-Mars rotation.

3.1. Rotation rate variations

The precision in determination of the amplitudes of variations in rotation rate could be slightly improved with a precise relative positioning of the rover (see Fig. 1). We thus should be able to better know the variations of the angular momentum due to seasonal mass transfer between the atmosphere and ice caps.

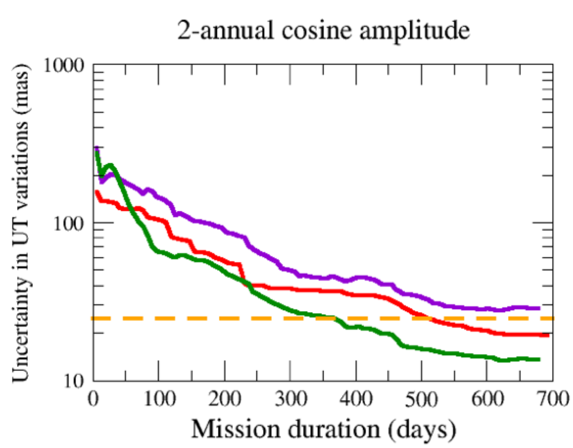

Figure 1: Uncertainties in rotation variations.

3.2. Precession

Precession should be determined with an accuracy better than the present-day accuracy after only a few months at the Martian surface. This precession determination will, in turn, improve the determination of the moment of inertia of the whole planet (mantle plus core) and the radius of the core. For a specific interior composition or even for a range of possible compositions, the core radius is expected to be determined with a precision decreasing to a few tens of kilometers.

3.3. nutation

Recent geodetic measurements [3] permit having a Free-Core-Nutation period extremely close to the ter-annual period of the forced nutation (229 days). This should induce a change in the nutation amplitudes, with respect to their values for a solid planet, at the percent level in the large semi-annual prograde nutation amplitude and even more (a few percent, a few tens of percent or more, depending on the FCN period) for the retrograde ter-annual nutation amplitude. The resonance amplification depends on the size, moment of inertia, and flattening of the core. For a large core, the amplification can be very large, ensuring the detection of the FCN (see Figs. 2 and 3), and determination of the core moment of inertia.

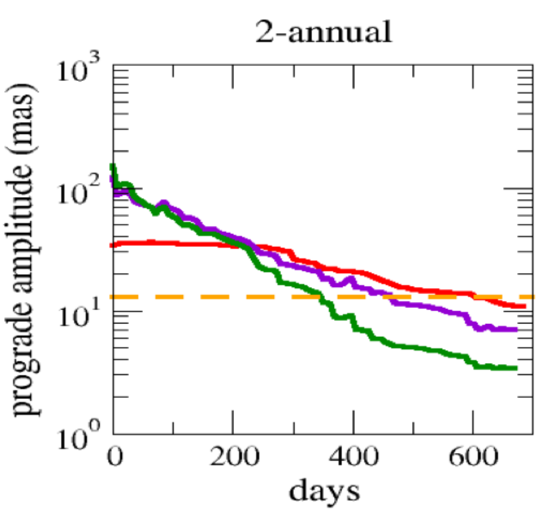

Figure 2: Uncertainties in semi-annual prograde nutation.

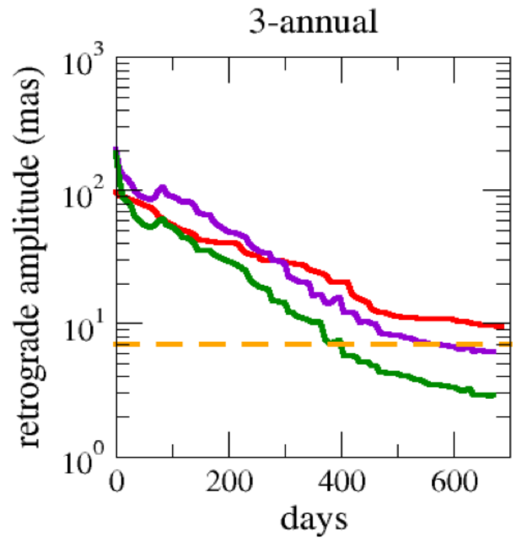

Figure 3: Uncertainties in ter-annual retrograde nutation.

Acknowledgements

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