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LaRa sensitivity to Mars nutations

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1 Introduction

LaRa (Lander Radioscience) is a radio-science experiment that will land on Mars in 2021 as part of the science payload of the Russian platform of the ESA/Roscosmos ExoMars 2020 mission. LaRa consists in an X-band coherent transponder accompanied with one receiving and two transmitting antennas[1]. The instrument is presented in details by Dehant et al. (this meeting). Its main scientific objective is to refine the rotation model of Mars in order to better constrain the planet's interior structure and atmosphere dynamics. In particular, LaRa will improve the current determination of the precession rate of the planet and measure its nutation precisely enough to quantify the effect of the liquid core [Dehant et al., 2019].

The work presented here focus on the ability of LaRa to determine the nutation of Mars. We analyse the impact of several operational and technical parameters on the determination of the semi-annual prograde nutation amplitude (p_2) and the ter-annual retrograde nutation amplitude (r_3). These amplitudes are considered to be of prime importance in the detection of the liquid core contribution in the nutation signal [Le Maistre et al., 2012].

We have studied the impact of several quantities, some of which will be shown and discussed like the impact of the measurements noise, the mission duration, the radio signal elevation and azimuth in the lander sky, the blackout periods, the on-board power availability, etc.

The comparative study presented here relies on numerical simulations performed using the GINS (Geodésie par Intégrations Numériques Simultanées) software. From this study, general conclusions can be drawn on the nutation determination from direct-to-Earth Doppler data provided by a landed mission (like ExoMars and InSight).

[1]Not to be used simultaneously, but implemented for redundancy reason.

2 Illustrative case of power availability

Many quantities related to the mission programmatic, the Doppler geometry, the instrument performances (e.g. antenna radiation pattern), etc., are expected to modify the data sensitivity to the targeted parameters and thus affect the scientific return of a radio-science experiment from a landed spacecraft. In order to optimise the benefit of the LaRa experiment, we designed the instrument and foresee its operations according to simulations' conclusions that are partly presented here.

For instance, as an illustrative case, we show in Fig. 1 the impact of power availability on the determination of p_2 and r_3. Assuming worse-case scenarios where LaRa operations would not be allowed while the Sun is not above a given elevation threshold (i.e. a given level of available power), the tracking opportunities could be significantly reduced, limiting the azimuth allowed during tracking, which can have strong impact on the nutation determination. Indeed, one can conclude from Fig. 1 that waiting for the Sun to be at minimum 15° of elevation above the lander is still acceptable, but higher elevation threshold would strongly reduce the science return of LaRa.

Acknowledgements

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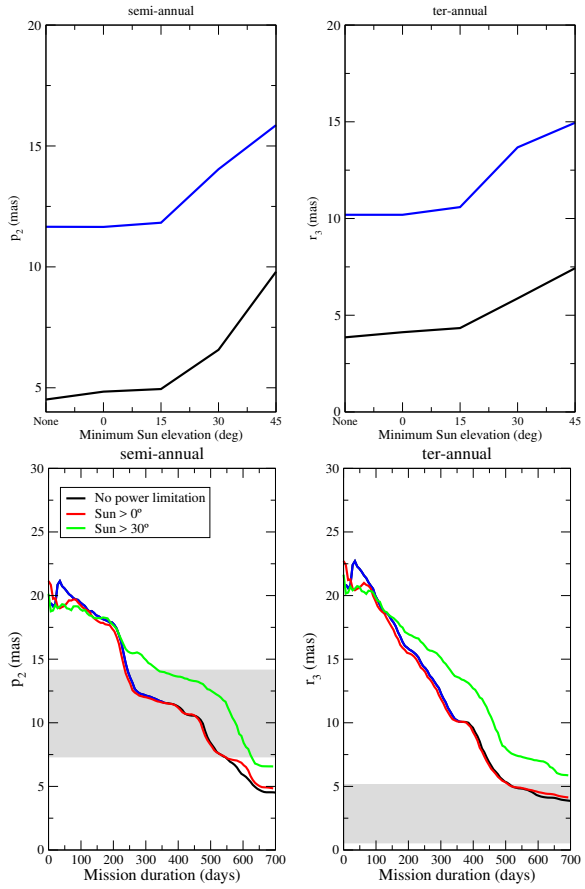

Figure 1: Impact of blackout periods due to power availability on the nutation determination. Solid curves are formal errors for different cases: no power limitations (blue after 300d, black after 700d), during the day at Mars (red in bottom panel), after about two hours of insolation (green in bottom panel). When the parameters uncertainties are smaller than the expected liquid core contribution to nutation, represented by these grey shaded boxes, then data accumulated by LaRa allow to detect the effect of the liquid core on the signal and thereby to constrain models of the deep interior of Mars.

References

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