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On the possible use of Phobos Grunt's radio-science data after landing on Phobos

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Abstract

Phobos Grunt spacecraft is expected to stay one year at the surface of Phobos. Thanks to 2-way Doppler data, this will be an opportunity to track Phobos satellite with an unprecedented accuracy. Here we focus on the benefit of such data to improve our knowledge of the Mars system and fundamental physics. Such experiment will provide a preview of what a space mission dedicated to Mars' geodesy, like the GETEMME mission [1], will bring.

1. Introduction

After its cruise of about one year, Phobos Grunt spacecraft will land on the closest moon to Mars, Phobos. Besides experiments dedicated to studying Phobos' surface, the spacecraft will communicate with the Earth regularly, providing the opportunity to track the orbital and rotational motion of Phobos. Even though a small part of the spacecraft will return to Earth bringing back Phobos' sample, most of Phobos Grunt instruments, like the radio-science one, will stay and still work at the Mars moon surface. In this work we focused on the possible determination of the temporal variation of Mars gravity field and relativistic parameter β using Phobos Grunt's data. Indeed, such physical effects may be fitted from Phobos orbital motion. Radio-science data will include both rotational and orbital motions. Fortunately, a star tracker onboard of the spacecraft will help decorrelating both signals.

2. Method

In this study, we assume that one year of data will be available with an accuracy of 10^{-1} mm/sec (note that a better accuracy may be expected, depending on the stability of the transponder coherency). We considered a uniform sampling of data, with 1, 000 data point per day. The use of uniform sampling has been chosen for simplicity, but is not expected to significantly influence the results.

To test the level of accuracy of the fitted parameters that one may expect with Phobos Grunt's radio-science data, we fitted a simulation without the physical effect of interest to a simulation that takes it into account (simulated observations).

3. Simulations

Below are provided the post-fit residuals associated to the two physical effects considered.

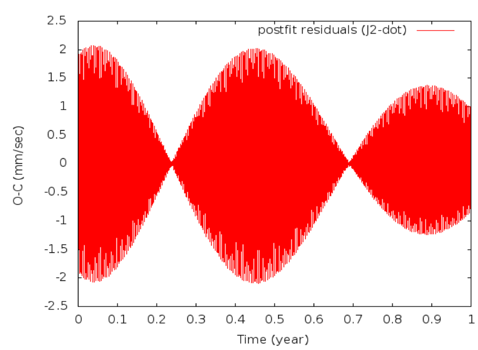

Figure 1: Post-fit residuals associated to the temporal variation of Mars' J_2.

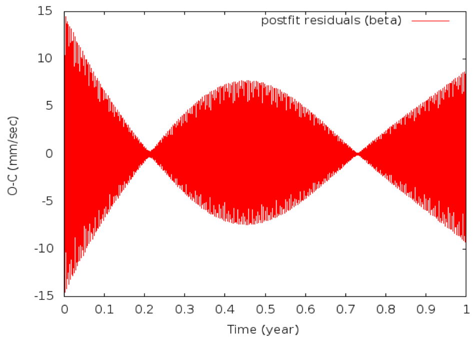

Figure 2: Post-fit residuals associated to the relativistic parameter β.

4. Tables

Table 1: formal 1-sigma error bar on the fitted parameters.

Physical effect	1-sigma	Today accuracy
Annual J_2	1.0×10^{-11}	few 10^{-9}
Semi-annual J_2	4.2×10^{-12}	few 10^{-9}
β	3.9×10^{-5}	10^{-4}

5. Conclusions

After one year of radio data, Phobos Grunt may provide the best estimation of both temporal variation of Mars' J_2 and relativistic parameter β. Our study let us expect that other relevant physical effects may be constrained with these data: Lense-Thirring, $\dot{G}/G$, Mars' k_2 (at different frequencies), secular $\dot{J}_2$,... It is also clear that the longest the spacecraft will be tracked at the Phobos' surface, the better the accuracy of the fitted parameters will be.

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References

[1] Oberst, J., Lainey, V., Le Poncin-Lafitte, C., and the GETEMME team: GETEMME - A mission to explore the Martian satellites and the fundamental of Solar system physics, submitted to Experimental Astronomy, 2011.