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Simulation of MPO orbit reconstruction using Doppler observations and comparison with laser altimetry observations

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Abstract

The BepiColombo Laser Altimeter (BELA) [1] will fly on board the European Space Agency's BepiColombo Mercury Planetary Orbiter (MPO). In this study, we present the MPO orbit reconstruction based on Doppler data with different settings on the arc lengths, arcs initial conditions, dynamical model, observation mode and orbit determination process and we compare the results of the orbit reconstruction with laser altimetry observables at crossover points.

1. Introduction

BepiColombo is Europe's first mission to Mercury [2]. It will set off in 2018 on a journey to the smallest terrestrial planet in our Solar System, Mercury. The mission comprises two spacecraft: MPO and MMO. The BepiColombo Laser Altimeter (BELA) is one of the instruments of MPO. The orbit of MPO spacecraft can be determined using Doppler tracking data [3]. But the contribution of laser altimetry observation at crossover points can potentially improve the accuracy of the determined orbit [4].

2. Modelling

For modeling the orbit of MPO around Mercury, we use a full force model containing all the gravitational and non-gravitational forces. The propagated orbit has been verified against orbits provided by DLR and ESA. Our simulations of Doppler tracking measurements include 2-way X-band and K-band Doppler measurements, station and planetary eclipses and the relativistic corrections and atmospheric effects.

To model the laser altimetry observation, we detect the location of crossover points based on the orbit and we simulate a series of laser altimetry observations around these points. Then we add both random and systematic errors to the observables based on the developed BELA instrument model [5] to have a realistic simulation.

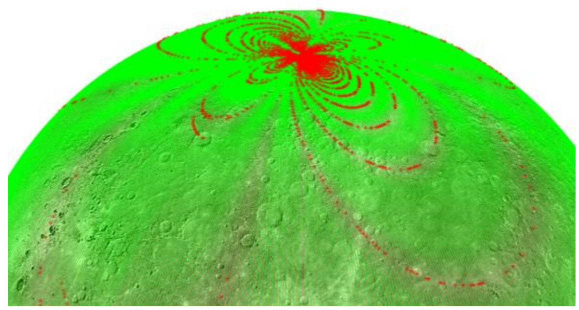

Figure 1: The distribution of crossover points in the first two months of mission (green lines are altimetry ground tracks and red points are crossover points)

For this study we use the planetary extension of the Bernese Software (BSW [6]). The latter is an advanced space data processing software developed at the Astronomical Institute of the University of Bern (AIUB).

3. Doppler Orbit reconstruction

We perform some orbit reconstruction tests using just the Doppler data with different settings on the arc lengths, arcs initial conditions, dynamical model, observation mode and orbit determination process in the Bernese software and we compare the results. For these tests, we use a full force model (Gravitational model w d/o 50, SRP, IR, Albedo) to produce synthetic Doppler data and a reduced force model with errors on the initial state vector as the knowledge of the orbit.

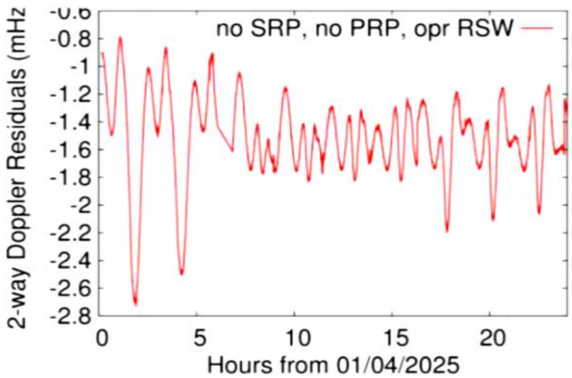

Figure 2: 2-way Doppler residuals in a simple orbit reconstruction test (RMS = 0.9 mHz over 60 days)

The goal of these tests is to find the best possible orbit determination accuracy that can be achieved using only Doppler data and the impact of different settings on the results. We also compare the results of Doppler-only orbit reconstruction with the altimetry crossover observables.

4. Summary and Conclusions

One of the final goals of this work is to study the impact of laser altimetry data in the form of crossovers to improve the orbit of the spacecraft. To achieve this, here we perform and present some orbit reconstruction tests using just the Doppler data with different settings and compare the results with previous studies. Finally, we compare the determined orbit with the laser altimetry crossover observables. such comparison can be used as both a validation/quality measure for the different tests and as a first step for including altimetry crossovers in the orbit recovery.

Acknowledgements

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