An independent solution for the precise orbit determination of Mercury planetary orbiter (MPO)

Alireza HosseiniArani1, Stefano Bertone3, Daniel Arnold2, Adrian Jäggi2, and Nicolas Thomas1

1Physics institute, University of Bern, Bern, Switzerland (seyedalireza.hosseiniarani@space.unibe.ch)
2Astronomical Institute, University of Bern, Bern, Switzerland
3NASA Goddard Space Flight Center (GSFC), USA

Navigation of deep space probes is most commonly operated using the spacecraft Doppler tracking technique. Orbital parameters are determined from a series of repeated measurements of the frequency shift of a microwave carrier over a given integration time. This study addresses the work that is done on Doppler orbit determination of MPO - one of the two spacecraft of the European Space Agency’s BepiColombo mission- using Bernese software.

For modelling the orbit of MPO around Mercury, we use a full force model, including Mercury gravity field GGMES-100V07 (up to degree and order 50), solid tides and third body perturbations. We also have an extensive modelling of non-gravitational forces that act on the orbit of spacecraft. This modelling includes the solar radiation pressure and planetary IR and albedo radiation together with a 33-plates macromodel of MPO. We propagate the orbit using this force model. Our simulations of Doppler tracking measurements include 2-way X-band and K-band Doppler measurements, station and planetary eclipses and the relativistic corrections.

The imperfect knowledge of the non-gravitational forces due to the proximity of Mercury to the Sun, together with the effect of desaturation maneuvers uncertainties, makes the use of the accelerometer necessary. Therefore, in our modelling of the orbit recovery, the models for the non-conservative forces were replaced by the noisy simulated accelerometer measurements. We find out that the modelling of the accelerometer noise has a huge impact on the results of the POD.

We perform several orbit reconstruction tests using daily arcs with noise modulated Doppler data with different settings on the arc lengths, arcs initial conditions, dynamical model, observation mode and orbit determination process and we solve for the initial state vector of each arc. We also run sensitivity analysis with respect to the different accelerometer model. The final goal of this study is to provide an independent solution for the precise orbit determination of Mercury planetary orbiter (MPO) using the planetary extension of the Bernese GNSS software. We present out latest results and then compare our results with the existing ones from the MORE team.
