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Influence of Low Callisto Orbit design on gravity field recovery

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Abstract

The gravity field of Callisto can be inferred using radio tracking data from a low-altitude orbiter around the icy moon. Orbit possibilities around Callisto are currently under study for the Gan De mission proposal [2]. However, gravity field recovery using Doppler observations is highly dependent on the orbit geometry. In this study, we will show the effect of different orbit constraints on the recoverability of Callisto's gravity field parameters.

1. Introduction

The exploration of Callisto is part of the extensive interest in the icy moons characterization. In comparison to the other Galilean moons, Callisto has kept the best-preserved records of the Jovian system formation. As other missions will focus on Ganymede and Europa, mission proposals devoted to the exploration and characterization of Callisto are currently emerging [2][6].

The Gan De mission [2] is at a very early planning stage. Led by the National Space Science Center (NSSC), Chinese Academy of Science (CAS), this mission aims to send an orbiter around Callisto in order to characterize its surface and interior. Its degree of differentiation will also be investigated as well as the possible existence of an internal ocean, as Galileo measurements suggested.

As part of a global characterization of Callisto, the recovery of gravity field parameters is highly dependent on the orbital characteristics of the mission. In this presentation, we will analyze the impact of the orbit choice for an orbiter around Callisto.

2. Exploring different orbits

Multiple flybys of Callisto are expected from the JUICE and the Europa Clipper missions [5]. Even if this will provide additional information on Callisto, the global mapping of the outermost Galilean moon will be uniquely improved by means of an orbiter from a high inclination and a low altitude. A specific difficulty in the orbit design in the Jovian system is related to the orbit stability, which is highly impacted by the influence of Jupiter as a third body exerting strong perturbations on a Callisto orbiter Another constraint is to maximize the illumination by the Sun for solar power, which is of importance especially for low-altitude probes in the outer solar system. These constraints will all have direct implications on the orbit parameters.

In this presentation, we will select a number of different low Callisto orbits for Gan De, respecting different of the above mentioned constraints, and analyze and compare their scientific value for gravity field recovery. We will explore different altitudes, Sun beta angles, Earth beta angles and mission durations. We will also analyze the possibility to use repetitive ground track orbits [3].

3. Gravity field recovery simulation

Using an extended force model, different reference orbits will be propagated in the planetary extension of the Bernese GNSS Software (BSW) [4]. Today, our knowledge of Callisto's gravity field is restricted to the results of the Galileo mission, which provided resulting its coefficients up to degree 2 coefficients [1]. In this presentation we will make use of a synthetic gravity field as ground truth for our simulation. Realistic Doppler tracking data (2-way X-band Doppler range rate) will be simulated as measurements from the Deep Space Network. These observations will then be used to reconstruct the orbit along with dynamical parameters. The focus of this presentation is on the quality of the retrieved gravity field parameters and tidal Love number k2.

Within this closed loop simulation, we will investigate the effect of the orbit geometry on the gravity field recovery. The effect of realistic tracking station schedule will also be considered, and an appropriate level of white noise will be added to synthetic Doppler observations.

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