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The detection of Jupiter normal modes with gravity measurements of the mission Juno

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Abstract

Arriving at Jupiter on July 4, 2016, NASA's Juno mission will complete 37 orbits (14-days period) around the planet, revealing details of the interior structure and composition, a crucial aspect to understand the origin and evolution of Jupiter. A radio science experiment will help to select and validate the existing models of Jupiter internal composition, in particular the mass of the silicate core.

The Juno radio science experiment exploits microwave radio link between ground stations and Juno to collect two-way range-rate measurements from the Doppler shift of a coherent Ka-band (32-34 GHz), two-way radio link. These data are processed through orbit determination codes to estimate both the position and velocity of the spacecraft at a given epoch, and additional parameters of scientific interest, such as the spherical harmonics coefficients of the gravity field. In addition, the experiment will provide an estimate of the angular momentum of Jupiter from the relativistic Lense-Thirring.

Recently it has been proposed to exploit the Doppler data for the determination of Jupiter's acoustic normal modes. Jupiter is a gaseous giant and its masses are subject to oscillations (normal modes) due to internal pressure waves, which cause potentially detectable disturbances in the gravity field. By displacing large masses, Jupiter's normal modes can therefore perturb the spacecraft motion to levels that can be measured by Juno's extremely accurate Doppler system. Theoretical models that explain these phenomena have been proposed in the past and experimental works looking for these oscillations have been carried out recently with ground-based optical telescopes. But the frequencies and the amplitudes of normal modes can in principle be modeled and estimated by means of orbit determination codes. This requires the modification of the mathematical model of the system's dynamics and the upgrade of the estimation filters.

The purpose of this study is to characterize the mathematical model that governs the normal modes of Jupiter and predict the associated power to each mode, based on published results. These works report the observation of a maximum radial velocity of the upper atmosphere of Jupiter of the order of 50cm/s at a peak frequency of 1200μHz. In this condition, the oscillation amplitude of Jupiter can potentially be so large to be observable by Juno.

In addition, the study focus on the observability conditions of the normal modes, also in relation to the spacecraft orbit geometry, and their discrimination from the static gravity field. Juno sensitivity to different dynamic gravity field coefficients at different frequencies is also being investigated. These goals are achieved by means of numerical simulations, providing in particular the estimation error, to be compared with the formal uncertainties of dynamic coefficients.