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DETERMINATION OF THE PLANETARY ROTATION BY IMAGING FROM ORBIT

Abstract

The knowledge of the rotational state of planetary bodies provides crucial information on their interior structure. Evolution models of the orbital dynamics use the obliquity as a constraint, together with the eccentricity. When the quadrupole gravity field is known, the obliquity may provide also the moment of inertia, one of the most important quantities to constrain the body's density profile. The spin rate and the physical librations provides a strong indication on the internal differentiation of a body, as well as information on the possible orbital resonances. Here we present a technique for the estimation of the rotational state of a body from orbit, with applications to Titan and Mercury. For Titan we have used existing SAR images from the Cassini mission, while for Mercury we relied on simulations of the optical observations from ESA's BepiColombo high resolution camera. Georeferenced images of the same area, taken at different times, are compared by pattern matching algorithms in order to determine the registration error. Different pattern matching procedures can be applied, as such as cross-correlation, mutual information technique, and SIFT/SURF algorithms. The mismatching is mainly due to errors in the rotational model, with smaller contributions from the spacecraft ephemerides and attitude, camera or radar calibration, and image processing. The image correlation is followed by a weighted least-squares fit to update the rotational model and minimize the mismatch between the features. The apparent misregistration of tiepoints is used to estimate the rotational parameters, such as the spin pole location, the spin rate and precession and nutation coefficients. We report on the results and the methods obtained for Cassini and BepiColombo, providing new estimates of the obliquity and spin rate of Titan and expected accuracies the obliquity and physical libration amplitude of Mercury. We discuss also the error budgets of both experiments.