Analytical description of physical librations of Janus and Epimetheus

Philippe Robutel (1), Nicolas Rambaux (2), and Julie Castillo-Rogez (3)

(1) IMCCE, Observatoire de Paris, CNRS UMR 8028, France (robutel@imcce.fr), (2) University Pierre et Marie Curie - Paris 6; IMCCE, Observatoire de Paris, CNRS UMR 8028, France, (3) JPL-Caltech, Pasadena, USA

Janus and Epimetheus are famously known for their distinctive horseshoe-shaped orbits resulting from a 1:1 orbital resonance.
Every four years these two satellites swap their orbits by a few tens of kilometers as a result of their close encounter. Recently Tiscareno \etal (2009) have suggested a model of rotation based on images from the Cassini orbiter. Assuming that the satellites follow a Keplerian orbit outside the swap, these authors inferred the amplitude of librational motion in longitude at the orbital period. By using an orbital model that includes the orbital swap, we characterize how that event impacts the rotation of the satellites. To that purpose, we have developed a formalism based on quasi-periodic series with long and short period librations. In this framework, the amplitude of the libration at the orbital period is found proportional to a term accounting for the orbital swap, which was absent from previous studies. From this approach we highlight a large error on the libration amplitude when the swap is neglected. We check the analytical quasi-periodic development by performing a numerical simulation and find both results in good agreement. Thus a robust determination of the librational motion of these satellites from observations requires to explicitly take into account the swap in the development.