IAA Transactions, No. 8, "Celestial Mechanics", 2002

Toward new ephemerides for the Galilean system

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The most accurate analytical ephemerides of the Galilean system are given from the Sampson–Lieske theory. This theory was originally made by Sampson at the beginning of the last century, and improved by Lieske during the seventies for the voyager spacecraft needs (see *Lieske*, 1977). Nowadays, these ephemerides are not precise enough beside the accuracy of the observations (about 50 kilometers for mutual phenomena). Moreover, the Galileo spacecraft (arrived on the Galilean system at the end of 1995), offers us the opportunity to improve, in a very straightening way, the modelling of this system.

We worked on the elaboration of a new semi–analytical theory of the Galilean satellites, able to fit the new observations over a long time span. In that respect, a very high sensitive model was used including most small perturbations such as satellites' oblateness, thanks to Galileo data.

Below are given all the perturbations introduced (see *Lainey et al.*, 2001 for details):

– the satellites' oblateness, which allow us to input the spin–orbit resonances in the system;
– indirect oblateness perturbation of Jupiter usually neglected;
– the solar perturbation by the use of the numerical theory DE406;
– other less influent perturbations such as relativistic effects, Amalthea, ...

We developed a method, based on numerical integration and frequency analysis, for reaching high–precision positions of the satellites. We used a numerical integrator with a constant step size of 0.08 day, over a time span longer than one thousand years (necessary for getting the periods of the nodes). The internal precision over such long span was estimated at few hundreds of meters. The semi–analytical series are computed by digital filtering and frequency analysis, for long period terms, and mostly by classical analytical development for short period terms. By coupling numerical methods with analytical development, we obtain at last an internal precision of few ten kilometers.

In order to approach our initial conditions and parameters to the true system, we adjusted our new theory with Sampson–Lieske theory. From this comparison some long period terms appeared. These differences which can reach 800 kilometers on Europa and 600 kilometers on Ganymede and Callisto are coming from the fact that the ampltiudes given in the Sampson–Lieske theory are constant. So the amplitudes can not be affected by long period changes. This shows the impossibility for the Sampson–Lieske theory to represent the motion of the satellites over one century with a high accuracy.

An adjustement to the observations is finally made by the use of the natural satellites data base of the IMCCE. Most of these observations were used in (*Arlot*, 1982) and reach a time span over one century from 1891 to 1990. This is still an ongoing work.

References

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