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Work on a New Solar-System Ephemeris: Status Report

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Currently, within a coordinated project in Germany, integrated methods and procedures for a consistent definition and realization of reference systems on Earth and in space are being developed. Barycentric ephemerides represent a dynamical realization of the Barycentric Celestial Reference System (BCRS), which is fundamental not only for the problem of interplanetary navigation but through its intimate relation to the Geocentric Celestial Reference System (GCRS).

In accordance with existing renowned ephemerides (INPOP, DE, EPM) we want to lay the foundation for a new solar-system ephemeris. We collected available observational data for the planets as well as high-precise tracking data to various spacecrafts (interplanetary probes, planetary orbiters and landers).

Furthermore, we set up the usual relativistic (post-Newtonian) force model in line with the latest French INPOP ephemeris, with a few exceptions. The focus in modeling is on the lunar librations and asteroid perturbations.

Regarding the treatment of the Moon, we draw upon the elaborated modeling within the existing LLR analysis software at IfE and its ongoing improvements. Nowadays, any modern ephemeris, besides perturbations due to general mass inhomogeneities (at least for the Earth and the Moon) and solar flattening, respective figure-figure interactions and tidal effects, proper rotations and librations etc., has to account for the significant gravitational effect of the vast number of minor bodies in the solar-system (especially within the major asteroid belt between Mars and Jupiter) on the long-term evolution of planetary orbits.

Due to limited computational resources, one is able to integrate the equations of motion (EOM) of only a comparatively small selection of asteroids simultaneously with the EOM of the major solar-system bodies (i.e. planets, Sun, Moon). On the other hand, one can efficiently account for the remaining asteroids by the introduction of at least one mass ring, the parameters of which (radius, total mass) have to be carefully modeled. Regarding the latter issue we will test the usability of an evolution strategy instead of a simple Monte Carlo method. In future, asteroid modeling will strongly benefit from observational data of the recently started GAIA mission.

Here we present a few statistics on the collected observational data, the fundamental force model of the EOM in detail, and first computational results in comparison with the INPOP ephemeris.