IMCCE PLANETARY SOLUTION: OVERVIEW AND PROSPECTS

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ABSTRACT. The VSOP solutions of the planetary motions are analytical solutions of the planets of the solar system, from Mercury to Neptune. These solutions have to give highly accurate ephemerides on long time intervals, about several thousand years for the inner planets and 1000 years of the outer planets. VSOP2002 (Bretagnon, 2002), the last unfinished VSOP version processed by P.Bretagnon, will be presented and its current accuracy will be discussed. A new analytical solution, VSOP2003, based on VSOP2002, is under development: Pluto perturbations based on the new analytical description of its motion (Simon 2003) are added, we introduce the developments of the mean short periods based on TOP (Simon, 2000), perturbations of the 300 asteroids are added with a one angular parameter model. In parallel, numerical solutions are also under development. Compared to VSOP solutions, these solutions will give more accurate positions and velocities of planets over shorter periods of time. Two types of solutions are considered: i) one follows the JPL integrator and algorithm. Its current status of development as well as the accuracies achieved by this version under process will be given during the talk. ii) one is based on the symplectic integrators developed by Laskar and Robutel (2001). It will be very accurate on short period of time (ten years) but also on very long period of time (several millions of years).

1. OVERVIEW

The VSOP solutions of the planetary motions are analytical solutions of the planets of the solar system, from Mercury to Neptune. These solutions have to give highly accurate ephemerides on long time intervals, about several thousand years for the inner planets and 1000 years of the outer planets. The perturbations are written as Poisson series of the mean mean longitudes λ. The main VSOP versions are the following: i) VSOP82 (Bretagnon, 1982), fitted to the JPL numerical integration, DE200 (Newhall et al, 1983) and written with elliptical variables, ii)VSOP87 (Bretagnon and Francou, 1988), built on VSOP82 in Cartesian and spherical variables and given in several reference frames, iii)VSOP200x (Moisson 2000, Moisson et Bretagnon 2001, Bretagnon, 2002). This last version was built in a relativistic frame, took into account the perturbations of Ceres, Pallas, Vesta, Iris and Bamberga, and it was fitted on DE403 (Standish et al, 1995). This version improved the VSOP82/87 with a factor 10 on small intervals of time. P.Bretagnon was still working on a new improved VSOP200x solution. In the following, we will call the last version of VSOP200x leaved by P.Bretagnon, VSOP2002.

The current accuracy of VSOP2002 will be discuss next. For Mercury, Venus and the Earth, the comparison to DE403 indicate an improvement of VSOP82 about a factor 40, and an improvement of the Moisson's solution about a factor 5. For the outer planets, the differences

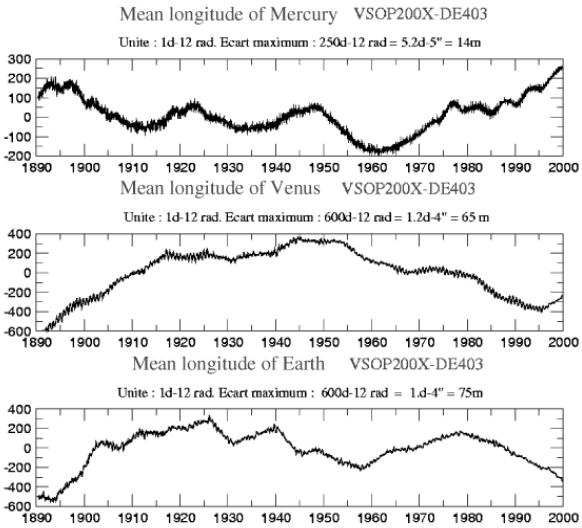

Figure 1: Differences, over [1890, 2000], between VSOP200X and DE403 for the mean longitudes of Mercury, Venus and the Earth-Moon Barycenter

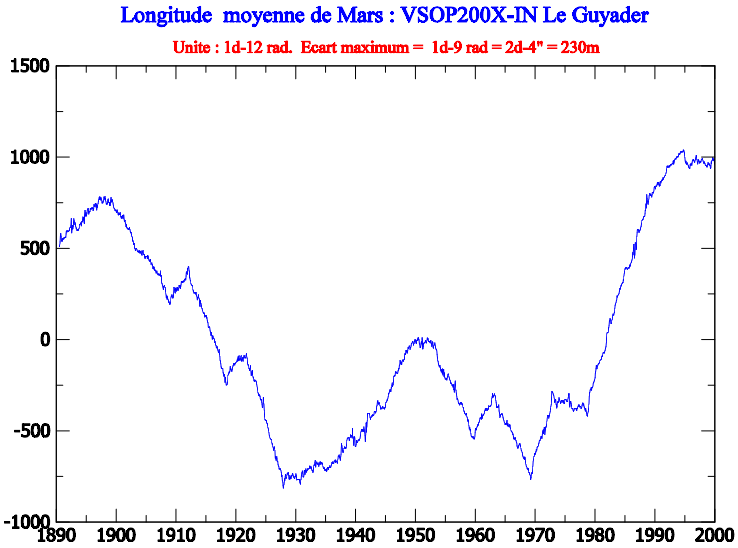

Figure 2: Differences in Mars mean longitudes, over [1890, 2000], between VSOP200X and a numerical integration without the 297 asteroides of DE403.

between VSOP2002 and DE403 are smaller than 750m for Jupiter and 3.5km for Saturn. It is an improvement of a factor 40 compared to VSOP82 and a factor 3 compared to VSOP200x. For Uranus and Neptune, the differences with DE403 are important because Pluto is not included in the solutions. Over 6000 years, the differences for the inner planets between VSOP2002 and an internal numerical integration show an improvement of VSOP82 of about a factor 10 to 100, depending of the planet. For the outer planets, the differences are important. They are induced by a bad behaviour of mean short periods as Poisson series of mean mean longitudes. An improvement of these terms in using the TOP theory (Simon, 2000) would be possible.

2. PROSPECTS

Based on these remarks, a new solution, VSOP2003, is under development.i) Pluto perturbations based on the new analytical description of its motion (Simon 2003) will be added, ii)

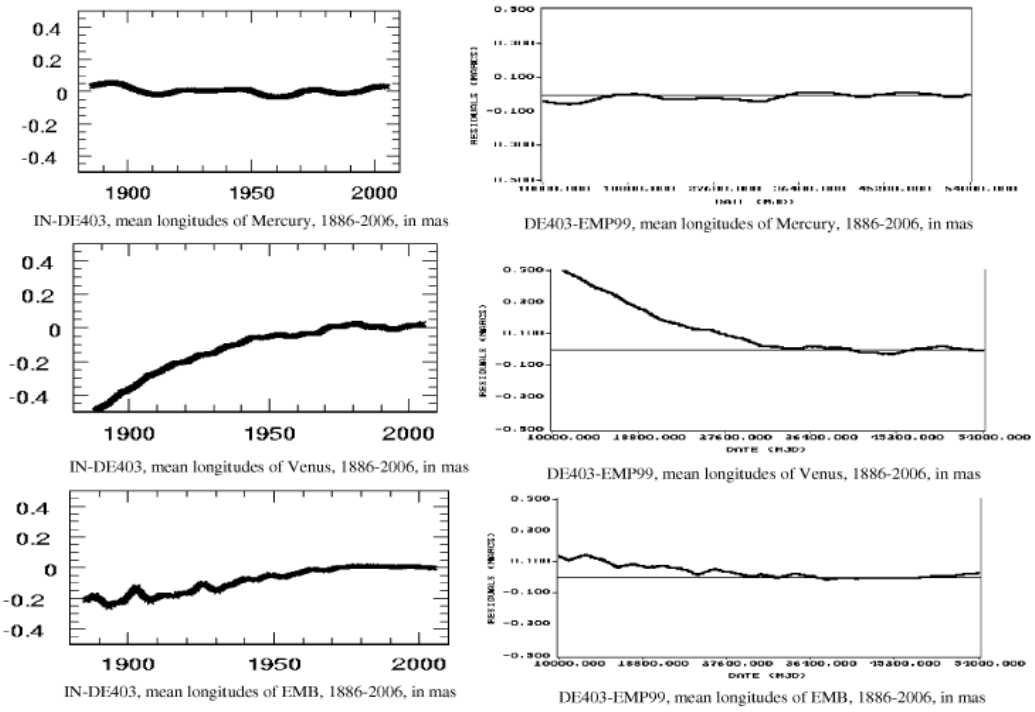

Figure 3: Comparisons between our new numerical integration and the EMP99 solution (Pitjeva 2001) for Mercury, Venus and the Earth-Moon barycenter (EMB).

In parallel, numerical solutions are under development. Compared to VSOP solutions, these solutions will give more accurate positions and velocities of planets over shorter periods of time. Two types of solutions are considered: i) one follows the JPL integrator and algorithm. It is based of the Moshier program (Moshier, 1992), and its current status is the following: the integration is done in a relativistic frame, perturbations of 300 asteroids are included, and it is fitted to DE403. This version will be used as tests for VSOP and a second, more accurate and more efficient numerical integrator, presented next. Accuracies achieved by this version under process will be given during the talk. ii) one is based on the symplectic integrators developed by

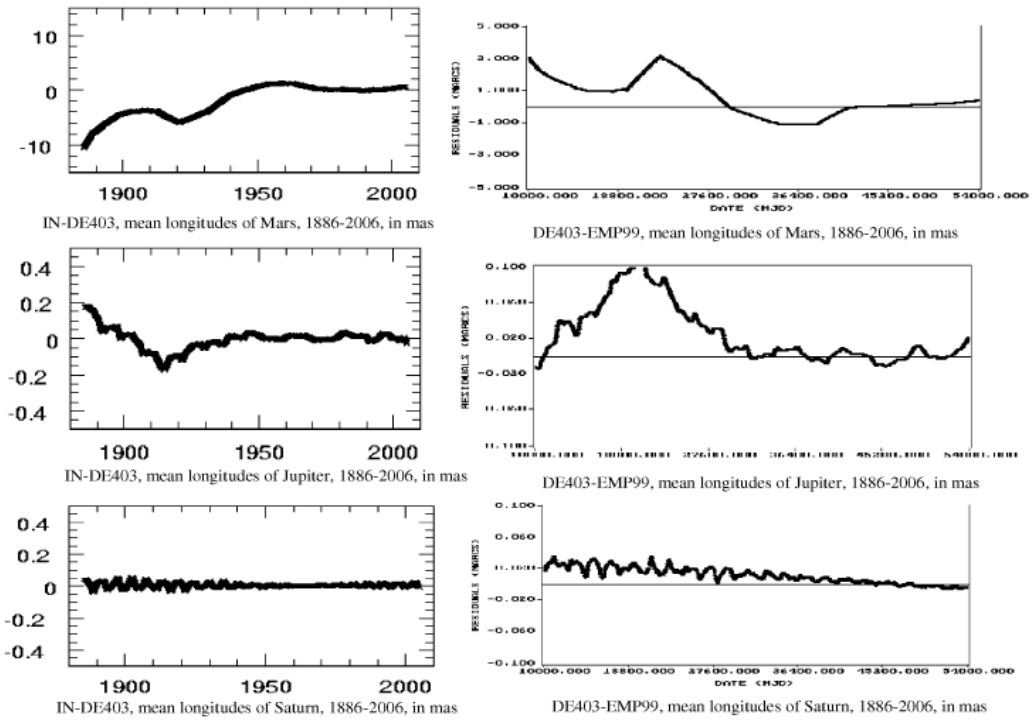

Figure 4: Comparisons between our new numerical integration and the EMP99 solution (Pitjeva 2001) for Mars, Jupiter and Saturn.

Laskar and Robutel (2001). The version will be tested versus the previous solution. It will be very accurate on short period of time (ten years) but also on very long period of time (several millions of years). It will also be stabler and more CPU efficient.

3. REFERENCES

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