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TOP2010 FILES
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J.-L. SIMON & G. FRANCOU
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INTRODUCTION
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TOP2010 is an analytical solution for the four 4 planets Jupiter, Saturn, Uranus, Neptune and for the dwarf planet Pluto.

The solution TOP2010 is fitted to the Ephemeris DE405 of the Jet Propulsion Laboratory(http://ssd.jpl.nasa.gov) over the time interval [1890-2000].

The reference system in the solution TOP2010 is defined by the dynamical equinox and ecliptic J2000 (Julian Date 2451545.0).

The TOP2010 file is named: TOP2010.dat


SOLUTIONS
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The file TOP2010 contains trigonometric series for the 6 elliptic variables which represent the motion of the planets. These series are functions of time (Periodic series and Poisson series).

List of the variables:

Elliptic elements:
Variable 1 :  a = semi-major axis (au)
Variable 2 :  $\lambda$ = mean longitude  (radian)
Variable 3 :  k = e*cos($\varpi$)
Variable 4 :  h = e*sin($\varpi$)
Variable 5 :  q = sin(i/2)*cos($\Omega$)
Variable 6 :  p = sin(i/2)*sin($\Omega$)
with:         e : eccentricity
              $\varpi$ : perihelion longitude
              i : inclination
              $\Omega$ : ascending node longitude

TOP2010 series are characterized by 3 parameters:
- the planet index from 5 to 9 (Jupiter, Saturn, Uranus, Neptune, Pluto),
- the variable index from 1 to 6 (a, $\lambda$, k, h, q, p),
                or from 1 to 3 (X, Y, Z or L, B, R),
- the time power $\alpha$ from 0 to 12.

TERMS OF SERIES
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The terms of series are given under the form: $T^{\alpha}$ ( C cos $\Phi$ + S sin $\Phi$ )

T     is the time from J2000 (JD2451545.0)
      expressed in Thousand of Julian Years (365250 days)


$\alpha$     is the time power of series (0 <= $\alpha$ <= 12).


C, S  are the coefficients for the variable a (au), the variable $\lambda$ (radian)
      and the variables, k, h, q, p (without unit).


$\Phi$     is the argument: $k.\mu.T$
      the coeffients k are integers and $\mu$ is equal to (n5-n6)/880 in radian
      where n5 and n6 are the mean motions of Jupiter and Saturn.


RECORDS ORGANIZATION
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There are two types of records.
"HEADER" record: Characteristics of series (planet, variable, time power).
"TERMS" records: Quantities k, C and S for each term of the series.

In the file TOP2010 the series are put in order of the planet (5-9) and the
variables (1-6), and, for each variable, in order of the time power $\alpha$.


HEADER RECORD
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Fortran Format:
      read (ifile,1001) ip,iv,it,nt
1001  format (22x,,i1,13x,i1,7x,i2,2x,i6)
ip : planete index                (integer)
iv : variable index               (integer)
it : time power $\alpha$                 (integer)
nt : number of terms in the series  (integer)

Planet index (ip):
5 : Jupiter
6 : Saturn
7 : Uranus
8 : Neptune
9 : Pluto

Variable index (iv):
1 : a,  X,  L
2 : $\lambda$,  Y,  B
3 : k,  Z,  R
4 : h
5 : q
6 : p

Time power (it):
=0 : Periodic terms
>0 : Poisson terms

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TERMS RECORD
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Fortran format:
      read  (ifile,1002) k,c1,ie1,c2,ie2
1002  format (1x,i8,2(f22.16,i4))


Each "TERMS" record contains respectively the quantities k, C and S.


Specifications:
k(i)  : numerical coefficient of µ      (integer)
c1    : mantissa of the amplitude C(i)    (real*8)
ie1   : exponent of the amplitude C(i)    (integer)
c2    : mantissa of the amplitude S(i)    (real*8)
ie2   : exponent of the amplitude S(i)    (integer)
p     : period expressed in years         (real*8)


The coefficients C and S are expressed in au for a, radian for λ, without
unit for the other variables k, h, q, p.



TIME SCALE AND REFERENCE SYSTEM
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The time used in TOP2010 series is TDB (Barycentrc Dynamical Time).
This time can be considered equal to TAI + 32.184 s.
TAI: International Atomic Time.

The solution TOP2010 is fitted to DE405 (Jet Propulsion Laboratory) over
the time interval [1890-2000].
The TOP2010 coordinates are referred to the inertial frame defined by the
dynamical equinox and ecliptic of J2000 (JD 2451545.0).
The planetary coordinates of DE405 are referred in a frame close by ICRF.
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If $X_E$, $Y_E$, $Z_E$ are the rectangular coordinates of a planet computed from TOP2010, the rectangular coordinates of the planet in equatorial frame of the ICRF, $X_Q$, $Y_Q$, $Z_Q$, may be obtained by the following rotation:

$$\begin{bmatrix} X_Q \\ Y_Q \\ Z_Q \end{bmatrix} = \begin{bmatrix} \cos\varphi & -\sin\varphi\cos\varepsilon & \sin\varphi\sin\varepsilon \\ \sin\varphi & \cos\varphi\cos\varepsilon & -\cos\varphi\sin\varepsilon \\ 0 & \sin\varepsilon & \cos\varepsilon \end{bmatrix} \begin{bmatrix} X_E \\ Y_E \\ Z_E \end{bmatrix}$$

with:   $\varepsilon$ = 23° 26' 21.40960"   et   $\varphi$ = -0.05028"

PRECISION
=========


The largest differences between TOP2010 and DE405 over the time interval
[1890 2000] give an estimation of the precision of the solutions TOP2010


| PLANET  | a      | λ    | k     | h     | q    | p    |
|---------|--------|------|-------|-------|------|------|
| Jupiter | 4.94   | 1.39 | 78.3  | 88.4  | 36.6 | 31.3 |
| Saturn  | 17.10  | 2.89 | 99.9  | 69.1  | 38.7 | 33.2 |
| Uranus  | 29.79  | 2.58 | 122.8 | 93.2  | 39.3 | 43.0 |
| Neptune | 43.66  | 1.52 | 70.6  | 67.5  | 42.0 | 43.0 |
| Pluto   | 130.49 | 3.42 | 161.6 | 149.7 | 26.5 | 23.9 |


Units: a (km), λ (mas), k, h, q, p ($10^{-10}$).



The largest differences between TOP2010 and DE406 over the time interval
[-3000 +3000] give an estimation of the precision of the solutions TOP2010
of Jupiter, Saturn, Uranus and Neptune for large time spans.


| PLANET  | λ    | L    | B    | R    |
|---------|------|------|------|------|
| Jupiter | 0.52 | 0.78 | 0.10 | 455  |
| Saturn  | 0.57 | 1.17 | 0.15 | 1717 |
| Uranus  | 0.53 | 0.63 | 0.04 | 1704 |
| Neptune | 0.22 | 0.35 | 0.03 | 2307 |


Units: mean longitude λ (arsecond),
Heliocentric longitude L and latitude B (arcsecond),
Distance Sun-Planet R (km).



COMPUTATION
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The program TOP2010.f (Fortran) computes the planetary elliptic elements
between 1890 and 2000 using the file TOP2010.dat.
This program computes also the planetary rectangular coordinates referred
to the dynamical ecliptic frame of J2000 and referred to the equatorial
frame of ICRS.

Parameters of the program TOP2010:
Starting date   : 1890 June 6 (DJ 2411544.5)
Number of dates : 11
Step            : 4000 days.

The results are given in the file: TOP2010.out.
The file TOP2010.ctl is given for checking these results.

ADDITIONAL FILES
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Two more files TOP2010 can be used for the 4 major planets Jupiter, Saturn, Uranus and Neptune.

1/ TOP2010XYZ.dat: this file contains the series of the rectangular heliocentric coordinates: X, Y, Z (au).

2/ TOP2010LBR.dat: this file contains the series of the spherical heliocentric coordinates: Longitude (L) and Latitude (B) in radian and the distance Sun-Planet (R) in astronomical unit.

These series are deduced from the series of elliptic variables given by the solution TOP2010 and the organization of these 2 files is the same as TOP2010.dat file.

The time scale (TDB) and the reference frame (dynamical ecliptic of J2000)) is those used in the solution TOP2010 and the reference system is defined by the dynamical equinox and ecliptic of J2000 (Julian Date 2451545.0).

The two programs TOP2010XYZ.f and TOP2010LBR.f (Fortran) computes 11 heliocentric rectangular and spherical coordinates of the 4 major planets, X, Y, Z and L, B, R, from 1890 to 2000 using respectively the files TOP2010XYZ.dat and TOP2010LBR.dat (step: 4000 days).

The results are given in the files: TOP2010XYZ.out and TOP2010LBR.out.
The files TOP2010XYZ.ctl and TOP2010LBR.ctl are given for checking these results.