

Recently, media have spoken of the Great conjunction (Jupiter and Saturn). It has been found interesting to use the SATELLITE Library of ESPSS to show how one can see those astronomical phenomena. Also, it is a relevant check of the validity of the equations used when forecasting the next great conjunction.

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Enhanced component **FramePlus** based on **Frame**

The SATELLITE Lib includes everything to locate all planets, Sun and Moon from Earth with respect to the equatorial plane and with respect to the vernal equinox direction γ (ECI equatorial frame). This is sufficient to compute the right ascension of those bodies (RA=angle in the equatorial plane between the body and γ), this can be seen also as a position in the sky belonging to some constellation of the zodiac). Because the coordinates are only internal variables of the component Frame, one cannot use them for further computations (unless the component is updated).

Hence, without update of the original component, a enhanced component **FramePlus** is needed for being able to use those internal variables:

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LIBRARY: SATELLITE
FILE: SATCompoFramePlus
CREATION DATE: 07/02/2021
-----
USE MATH
USE SATELLITE
-- ' 08/02/2021 08:52:18
COMPONENT FramePlus IS_A Frame "add the RA Right ascension and declination of the planets for enabling the plot of the RA versus the time for all the planets"

DECLS
EXPL REAL RAPlanet{Sol}          UNITS u_rad "Planet Right ascension seen from Earth i.e. in ECI Equatorial frame"
EXPL REAL DecPlanet{Sol}        UNITS u_rad "Declinaison seen from Earth i.e. in ECI Equatorial frame"
EXPL REAL Tday "Time in days"

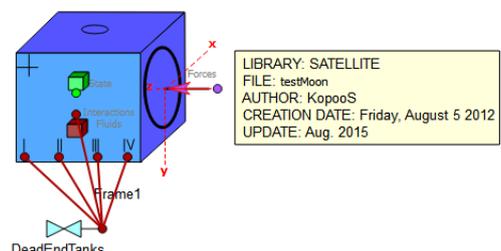
CONTINUOUS
Tday=TIME/86400
EXPAND_BLOCK (i IN Sol EXCEPT Earth)
    -atan2( y, x) inverse tangent of y/x in the range of [-PI; PI] radians. Note that in other tools (eg Excel) the definition is different.
    RAPlanet{ij}= deg(atan2(RplanetsToEarth{ij},Yqj),RplanetsToEarth{ij},Xqj), FALSE,FALSE)-- RA seen from Earth ECI equatorial tan(RA)= y/x
    DecPlanet{ij}= deg(atan2(RplanetsToEarth{ij},Zqj),sqrt(RplanetsToEarth{ij},Xqj**2+RplanetsToEarth{ij},Yqj**2)), FALSE,FALSE)-- delta
    declin seen from Earth ECI equatorial tan(decl)= z/(x**2+y**2)^.5
END EXPAND_BLOCK
END COMPONENT
    
```

Plot of Planets trajectory versus time in terms of right ascension

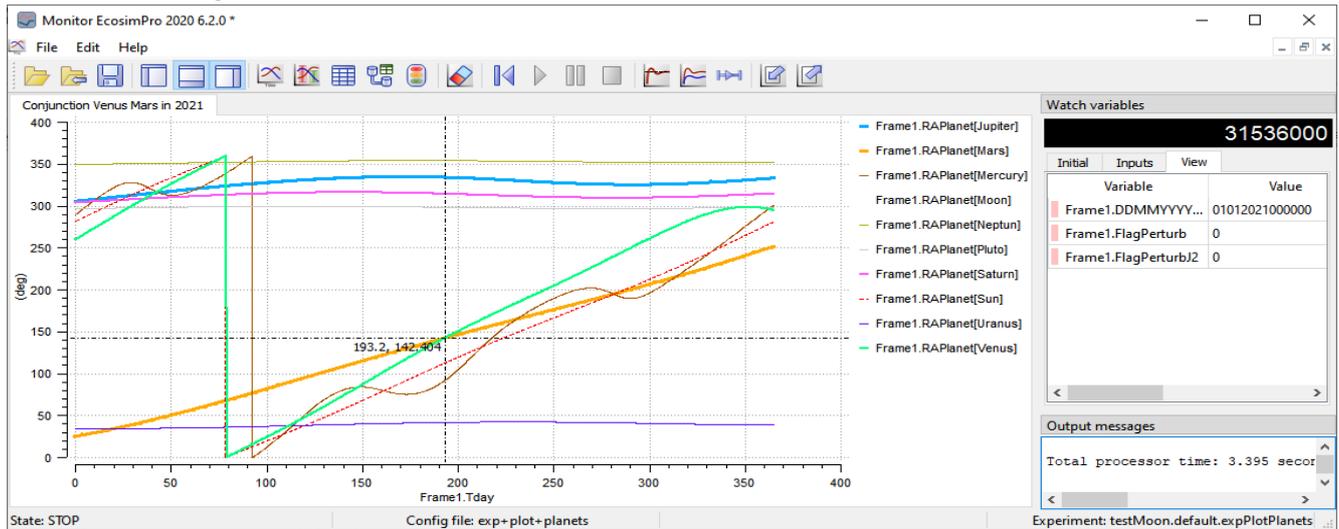
Such plots are very interesting for the possibilities to see the planets after sunset or before sunrise as well as for locating the astronomical events like conjunctions between planets, etc.; *ref. Astronomy Lab 2 v. 2.03 by Eric Bergman-Terrell, 1995.*

Model

One uses the existing model testMoon, changing the Frame1 by the new component FramePlus



Results for year 2021



- The Sun right ascension is plotted in dotted red diagonal line. Mercury trajectory (brown), seen from earth, oscillate around the Sun. At a least extent, Venus (light green) oscillate too around the Sun. Other planets trajectories (in terms of RA) are almost constant: that means that they stay each one all the year 2021 about in the same constellation in the sky (except Mars).
- At near left of the Sun trajectory, this can be seen as evening after the sunset, so in the year 2021, Mars (orange) will be seen after the sunset up to day 280 (September). After that date, Mars is at right of the Sun, so may be only visible before the sunrise.
- The conjunction Mars Venus occurs at day 193.2 because those two planets have same right ascension. This will be seen in the evening after the sunset for a RA of 142° (i.e. in the constellation of Leo).
- The Great Conjunction of December 2020 is still a bit visible in the evening in the first days of 2021 : Jupiter (light blue) and Saturn (pink) are very near together at left of the Sun.

Results for years 2020-2040



- The full trajectory of Jupiter can be seen on this extended plot (there are almost 2 Jupiter periods).
- The 2020 Great Conjunction occurred on day 351.8 (mid December 2020)
- The next Great Conjunction will occur on day 7609.6 (November 2040)
- The period between those conjunctions is 7257.8 days (19.87 years), i.e. about 20 years which is a well-known data.
- This prove the long term validity of the equations used in ESPSS SATELLITE lib for the planets.