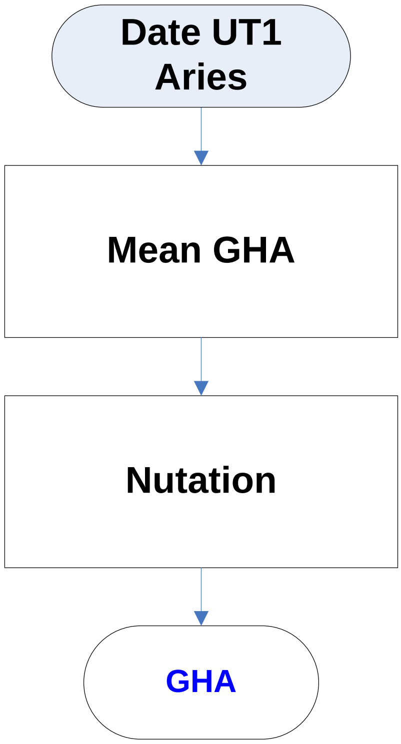
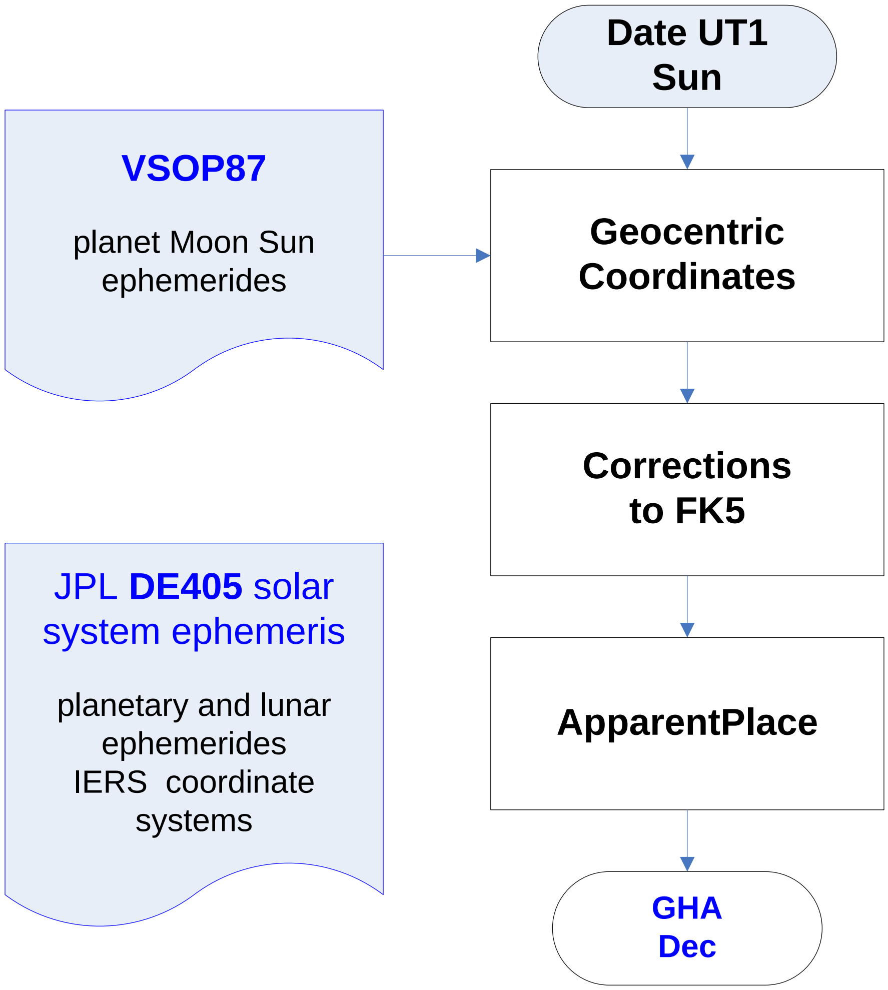
NAVIGATIONAL ALGORITHMS
Astronomía de Posición

© Andrés Ruiz
San Sebastián – Donostia
43º 19'N 002ºW
http://www.geocities.com/andresruizgonzalez

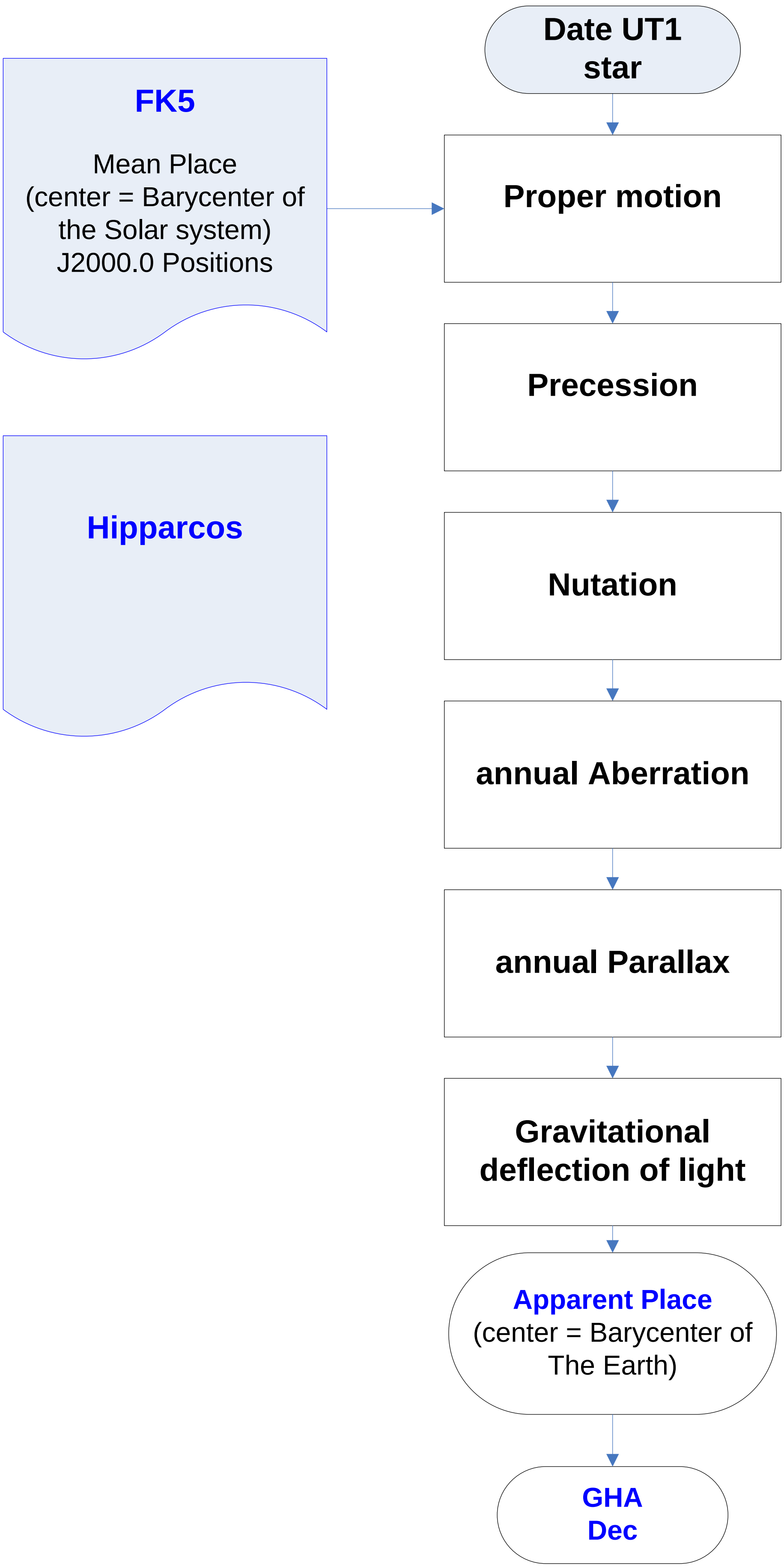
First point of Aries



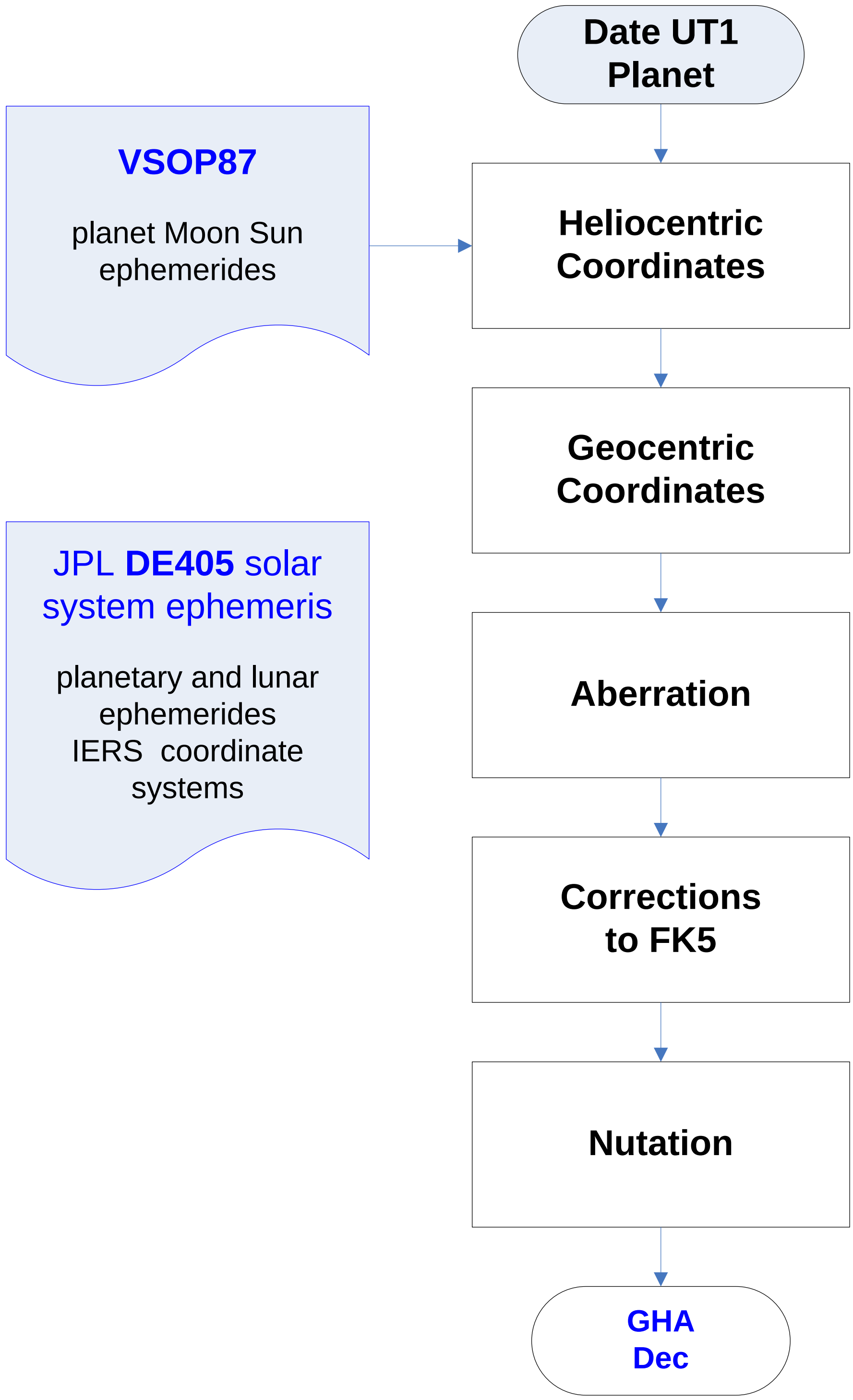
Positions of the Sun



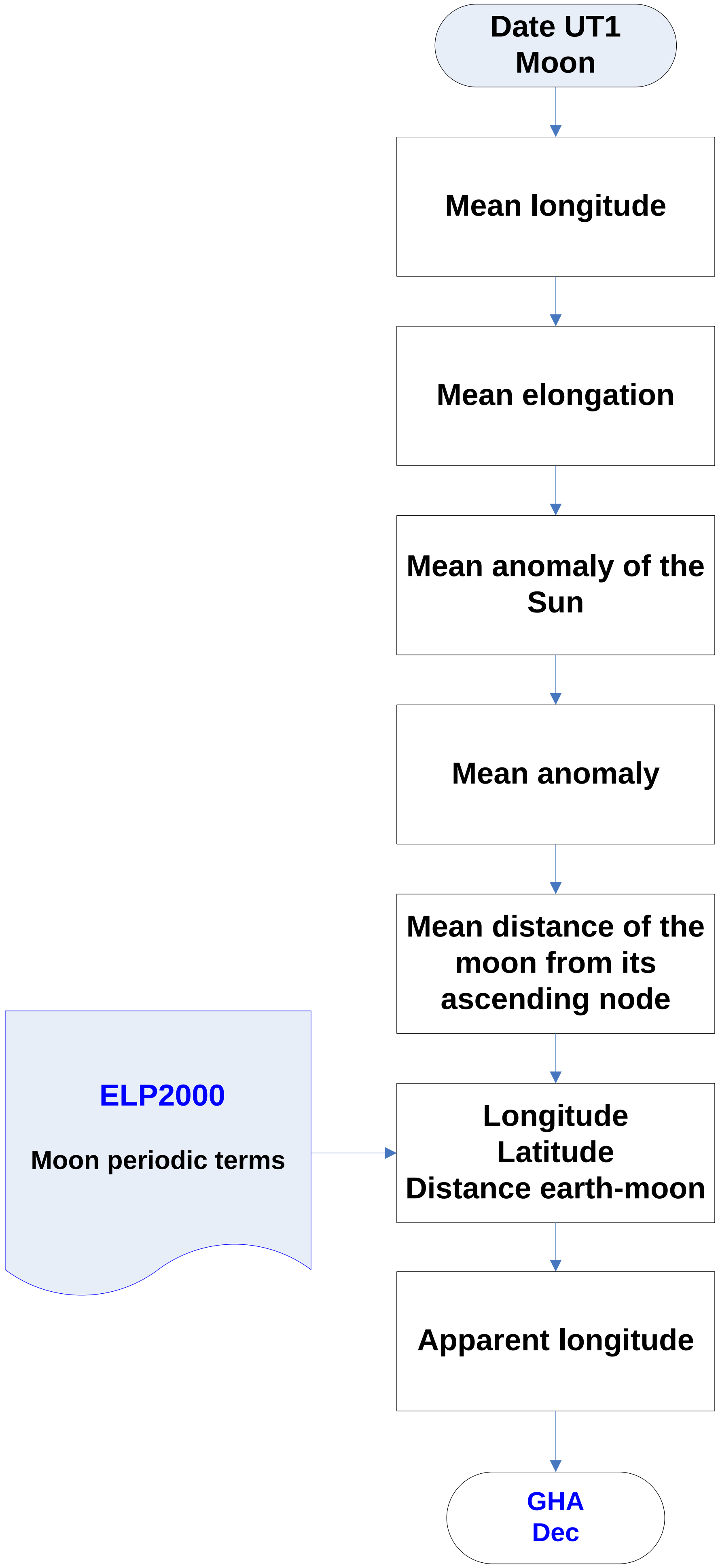
Apparent place of a Star



Positions of the Planets



Position of the the Moon



Indice

Día juliano / Julian day

The number of each day, as reckoned consecutively since the beginning of the present Julian period on January 1, 4713 BC. It is used primarily by astronomers to avoid confusion due to the use of different calendars at different times and places. The Julian day begins at noon, 12 hours later than the corresponding civil day. The day beginning at noon January 1, 1968, was Julian day 2,439,857.

Julian calendar. A revision of the ancient calendar of the city of Rome, instituted in the Roman Empire by Julius Caesar in 46 B.C,, which reached its final form in about 8 A.D. It consisted of years of 365 days, with an intercalary day every fourth year. The current Gregorian calendar is the same as the Julian calendar except that October 5, 1582, of the Julian calendar became October 15, 1582 of the Gregorian calendar and of the centurial years, only those divisible by 400 are leap years.

Bibliography: Astronomical Algorithms by Jean Meeus. 2 Ed edition (December 1998). ISBN: 0943396638

Variables

JD	the Julian day
D	Day, (current Gregorian calendar)
M	Month
Y	year
Hour	GMT/UT time
Min	Minutes
Sec	Seconds
floor(x)	function that returns a floating-point value representing the largest integer that is less than or equal to x. The floor of 2.8 is 2.0 The floor of -2.8 is -3.0

Algorithm

```
D = D + (hour+min/60.0+sec/3600.0)/24.0;
if( int(M) == 1 || int(M) == 2 ) {
          Y = Y-1.0;
          M = M+12.0;
          }
A = floor(Y/100.0);
B = 2.0-A+floor(A/4.0);
if( calendar == 'Julian' ) B = 0.0;
JD = floor(365.25*(Y+4716.0)) + floor(30.6001*(M+1.0)) +D+B-1524.5;
```

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Angulo Horario en Greenwich de Aries.
Greenwich Hour Angle of Aries

Sidereal Time At Greenwich. **Sidereal time** is defined by the daily rotation of the earth with respect to the vernal equinox of the first point of Aries. Sidereal time is numerically measured by the hour angle of the equinox, which represents the position of the equinox in the daily rotation. The period of one rotation of the equinox in hour angle, between two successive upper meridian transits, is a sidereal day. It is divided into 24 sidereal hours, reckoned at upper transit which is known as sidereal noon. The true equinox is at the intersection of the true celestia equator of date with the ecliptic of date; the time measured by its daily otation is apparent sidereal time. The position of the equinox is affected by the nutation of the axis of rotation of the earth, and the nutation consequently introduces irregular periodic inequities into the apparent sidereal time and the length of the sidereal day. The time measured by the motion of the mean equinox of date, affected only by the secular inequalities due to the precession of the axis, is mean sidereal time. The maximum difference between apparent mean sidereal times is only a little over a second and its greatest daily change is a little more than a hundredth of a second. Because of its variable rate, apparent sidereal time is used by astronomers only as a measure of epoch; it is not used for time interval. Mean sidereal time is deduced from apparent sidereal time by applying the equation of equinoxes.

Accuracy: GHA Aries less than ±0.02'

Bibliography:

Astronomical Algorithms by Jean Meeus. 2 Ed edition (December 1998). ISBN: 0943396638

Variables

JD	the Julian date
theta0	Mean GHA of Aries
ang_0_360(x)	Function to put an angle into the limits of: 0º < x < 360º
deltaPsi	Nutation in longitude
epsilon	True obliquity of the ecliptic

Algorithm

```
T = (JD - 2451545.0 ) / 36525.0;
theta0 = 280.46061837 + 360.98564736629*(JD-2451545.0) +
0.000387933*T*T - T*T*T/38710000.0;
theta0 = ang_0_360(theta0);
GHA = theta0 + deltaPsi*COS( epsilon );
```

The term deltaPsi*COS(epsilon), take account of Nutation, obliquity of the ecliptic. And can be ignored if the accuracy of ±0.02' is not necessary

```
GHA = ang_0_360( GHA );
```

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El Sol, coordenadas aproximadas.
The Sun, approximate coordinates

Sun's angular coordinates to an accuracy of about 1 arcminute within two centuries of 2000.

- RA. Right ascension
- Dec. Declination

Algorithm

```
// D: the number of days and fraction (+ or -) from the epoch referred to as J2000.0,
// which is 2000 January 1.5, Julian date 2451545.0:
// JD: the Julian date
day = day + (hour+min/60.0+sec/3600.0)/24.0;
JD = JulianDate( day, month, year );
D = JD-2451545.0;
// all the constants (therefore g, q, and L) are in degrees.
g = 357.529+0.98560028*D;
q = 280.459+0.98564736*D;
// L: approximation to the Sun's geocentric apparent ecliptic longitude (adjusted for
aberration).
L = q+1.915*SIN( g )+ 0.020* SIN( 2.0*g );
// Reduce g, q, and L to the range 0° to 360°
g = ang_0_360( g );
q = ang_0_360( q );
L = ang_0_360( L );
// Sun's ecliptic latitude, b, can be approximated by
b = 0.0;
// The distance of the Sun from the Earth, R, in astronomical units (AU)
R = 1.00014-0.01671*COS( g )-0.00014*COS( 2.0*g );
// mean obliquity of the ecliptic, in degrees:
e = 23.439-0.00000036*D;
// right ascension in degrees
// RA is always in the same quadrant as L.
// RA = ATAN( COS( e )*SIN( L )/COS( L ) );
// the proper quadrant will be obtained.
RA = ATAN2( COS( e )*SIN( L ), COS( L ) );
// right ascension in hours
RA = RA/15.0;
// Reduced to the range 0h to 24h
RA = time_0_24( RA );
// declination
Dec = ASIN( SIN( e )*SIN( L ) );

// The Equation of Time, apparent solar time minus mean solar time
// Eqt and RA are in hours and q is in degrees.
EqT = q/15.0 - RA;
// angular semidiameter of the Sun in degrees
SD = 0.2666/R;
```

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Compact Data for Navigation and Astronomy

Ephemerides

The almanac data is calculated from GMT/UT:

- GHA
- DEC
- HP
- Semi-diameter

Variables

GMT	Greenwich Mean Time. Universal Time (UT).
Lat or B	Latitude (north = positive, south = negative)
Long or L	Longitude (east = positive, west = negative).
GHA	Greenwich Hour Angle = GHA(Aries) + SHA in degrees E from 0° to 360°.
SHA	Sidereal Hour Angle = 360° - Right Ascension.
DEC	Declination in degrees north (positive) and south (negative).
LHA	Local Hour Angle = GHA + Longitude in degrees E from 0° to360°. LHA = GHAAries + SHA +/- observer's longitude
HP	Horizontal Parallax of Sun, Moon, Venus or Mars.
PA	Parallax in Altitude of Sun, Moon, Venus or Mars. PA = HP * cos H
S	Semi-diameter of the Sun or Moon. (Add lower limb and subtract upper limb).

Sun

The calculations in the method using the coefficients are:

Time variable x = (d + GMT / 24) / 32.

d is the day in the month and GMT the universal time in hours.

Using x, (GHA - GMT) in hours and DEC in degrees are derived from this expression:

a0 + (a1 * x) + (a2 * x2) + (a3 * x3) + (a4 * x4)

This can be rewritten as:

(((a4 * x + a3) * x + a2) * x + a1) * x + a0

You can convert the GHA in hours to degrees by adding GMT and multiplying the result by 15 to convert from hours to degrees.

The semi-diameter is calculated using the expression

S = a0 + (a1 * x)

Stars

The algorithms are similar to the Sun:

Calculate time variable L

L = 0.9856474 * (D + d + GMT / 24)

D = Number of days from 0:0:0 on 1/1/91 or 1/1/96. d is the day of the month.

For information **GHA(Aries)** can be derived from 98.9513° + L + (15 * GMT in decimal hours)

The expressions for the GHA and DEC are:

GHA = a0 + (a1 * L) + (a2 * sin L) + (a3 * cos L) + (15 * GMT in decimal hours)
DEC = a0 + (a1 * L) + (a2 * sin L) + (a3 * cos L)

No semi-diameter is required for stars.

Moon

The method uses a complex set of algorithms to derive the GHA, DEC and HP.

Planets

The calculations using the coefficients are the same as for the Sun:

Time variable x = (d + GMT / 24) / 32.

d is the day in the month and GMT the universal time in hours.

(GHA - GMT) in hours and DEC in degrees are derived from this expression:

a0 + (a1 * x) + (a2 * x2) + (a3 * x3) + (a4 * x4)

The horizontal parallax is calculated using the expression

HP = a0 + (a1 * x)

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