

## Predicting Equinoxes and Solstices

This *Numerit* program (`equsol`) determines the time of the equinoxes and solstices of the Earth. The time of equinoxes and solstices determine the beginning and end of our seasons. These events are the times when the apparent geocentric longitude of the Sun is an exact multiple of 90 degrees. This software uses Brent's root-finder and the `sun1` solar ephemeris to calculate these events.

Brent's method requires an objective function which defines the single nonlinear equation to be solved. The objective function for the spring and fall equinoxes is the geocentric declination of the Sun. For the summer and winter solstices the objective function is  $q - I_s$ , where  $q = 90^\circ$  for the summer solstice,  $q = 270^\circ$  for the winter solstice and  $I_s$  is the geocentric apparent longitude of the Sun.

Brent's method also requires an initial and final time which bounds the root of the objective function. The initial time for the spring equinox is March 15, for the summer solstice June 15, for the fall equinox September 15 and for the winter solstice December 15. For each event, the final time is equal to these initial dates plus 15 days.

The following is the *Numerit* source code for this objective function:

```
function esfunc(x, fx)
` equinox/solstice objective function
` Celestial Computing with Numerit
.....
jdate = %jdatei + x
` compute coordinates of the sun
sun1 (jdate, rasc, decl, rsun)
` iequsol flag determines if this
` is an equinox or solstice

if (%iequsol = 1 or %iequsol = 3)
    fx = decl
else
    fx = %along2 - %rlsun
```

This code returns a function value `fx` for any input time argument `x`. The type of calculation performed by this function is determined by the value of the `%iequsol` "flag". This flag is set by the main program. In this listing `decl` is the declination of the Sun, `along2` is the apparent longitude of the event and `rlsun` is the apparent geocentric longitude of the Sun.

## *Celestial Computing with Numerit*

This program will prompt you for the calendar year of interest. The following is a typical draft output created with this program. Please note that the event is displayed in dynamical or ephemeris time.

time of the equinoxes and solstices

spring equinox

calendar date    March 20, 2000

dynamical time   7 h 36 m 11.4938 s

summer solstice

calendar date    June 21, 2000

dynamical time   1 h 48 m 48.2259 s

fall equinox

calendar date    September 22, 2000

dynamical time   17 h 28 m 44.6439 s

winter solstice

calendar date    December 21, 2000

dynamical time   13 h 38 m 29.9393 s