Ephemeris for HP49G+/HP50G
EPHE version 2.13

1 Introduction

1.1 Presentation

- EPHE can compute ephemeris of :
- The Sun,
- Planets,
- The Moon,
- Stars,
- Messier Objects,
- Comets,
- Asteroids.

The computation is made according to the observer's position, and date and time of observation.

Positions of celestial objects can be computed in several systems of coordinates :
- Geocentric Ecliptic Coordinates (Geocentric longitude and latitude),
- Equatorial Coordinates (right ascension and declination),
- Hour Coordinates (hour angle and declination),
- Horizontal Coordinates (azimuth and altitude).

Depending on the object, more data is computed :
- Distance,
- Magnitude,
- Apparent Diameter,
- Phase.

This software is also able to compute rising, setting and meridian crossing times, for a given object.
It also computes date and time of solstices and equinoxes (seasons beginning).

When computing, the software displays each step of computation.
Results are displayed in a formatted form.

1.2 Bibliography

Algorithms and data in EPHE are based on the following books :

- Calcul Astronomique pour Amateurs, 4ème édition, Author : S. BOUIGES, Editor : Masson.
- Astronomie Pratique et Informatique, Author C. DUMOULIN et J.-P. PARISOT, Editor : Masson.
- Astronomy with your Personal Computer, 2nd Edition, Author : Peter DUFFETT-SMITH, Editor : Cambridge University Press.
- Ephémérides Astronomiques 1996, Annuaire du Bureau des Longitudes, Editor : Masson.
- Ephémérides Astronomiques 1998, Annuaire du Bureau des Longitudes, Editor : Masson.

2 Instructions for Installation

2.1 Required Configuration

EPHE has initially been developed on a HP48SX, with a 128 KB RAM extension (EPHE version 1.xx).
Then the program has been ported to a HP49G+ (version 2.xx).

The EPHE library total size is 86 KB.
After installation, the directory created for variables and databases is : 4 KB.

This document is written for a HP49G+ configured in RPN mode.

2.2 Installation

- Download the library file 'ephe2xx' into your HP49G (binary mode).
- Put the library into the stack. 'Library 1769: Ephemeris' should be in the stack.
- Store this library into the port you chose. (1 STO, for example).
  Then, the variable containing the library can be deleted.
- To attach the library, just do a soft reset ON + F3 C.

In the LIB menu (↱ 2), a new menu item is available : **Ephem**. When typed, it displays two other menu items :

- **Insta** : allows to create a directory 'Ephe' in the VAR menu. This directory is containing variables to be used by the program, and a user's menu. When the directory is created, 'Ephe' becomes the active directory ({HOME Ephe}), and the user's menu is displayed, to allow an immediate use.
- **Info** : displays a presentation screen.

Notes :

- 'Ephe' directory is not supposed to be in the root directory. You only have to go to the desired target directory, before typing **Insta**.
- After installation, to display the software menu, you must use the user's menu key (CUSTOM menu, ↰ MODE), from the 'Ephe' directory. You should not use **Insta** again, if you don't want to loose your configuration and database modifications.

To uninstall EPHE :

- Purge the 'Ephe' directory ('Ephe' PGDIR),
- Remove the library from memory (:1: 1769 PURGE, for memory port 1).

2.3 Indicators

EPHE uses the user's binary indicators from number **50** to **55**, to save the configuration.

When computing, the following system indicators are modified :

- **-15** and **-16** for spherical mode,
- **-17** and **-18** for angles in degrees mode.

When exiting, system binary indicators are restored, as they were before starting.

2.4 Number of display lines

The program adapts its screens size according to the HP49G+ header size, defined with parameter **Header** in MODE **Disp**.

All screens shown in this documents were generated with a **Header** value at 2 lines.

3 Ephemeris Computation

3.1 Displaying the Menu

To display the EPHE menu, just go into the 'Ephe' directory ({HOME Ephe}), and type CUSTOM key
(↰ MODE - user's menu).
Then, the EPHE menu should be displayed at the bottom of the screen.

3.2 Software Parameters (First line of menu)

Init Place DST■ Engl Disp End

The first two lines of the menu (initial one, and the one displayed after typing NXT) are used to define software parameters.
Parameters to be defined first are observation time and observer's location.

3.2.1 Date Initialization Init

This menu item is used to initialize date and time.

Initialization process depends on the number of parameters in the stack when you type **Init**.

- No parameter : HP49 date and time are used.
  (Time Zone parameter must be defined : *see paragraph 3.2.3*).
- 1 parameter : it is used as the **universal time** (UT). The HP49 date is used.
- 2 parameters : first one is used as the date, and second one, as the UT time.

Following formats must be used for date and time parameters :

- date : dd.mmyyyy or mm.ddyyyy (depending on system date format, indicator -42),
- time : hh.mmss (CAUTION : 24 h format, 0 ≤ hh < 24).

These formats are also used for results displaying.

After initialization is performed, the following data is displayed :

- Observer's location,
- Observation date,
- Julian date,
- Universal time,
- Sidereal time in Greenwich at 0 h TU,
- Local sidereal time.

```
Initialization
Place: Washington
Date dmy: 12.112005
Jul Date: 2453687.5782
UT   hms: 1.5238
GST0 hms: 3.2454
SidT hms: .0934
```

3.2.2 Location Place

This menu item is used to define the observer's location. If place has not been modified since last program run, it remains defined, and you don't need to set it again.

A database containing several locations is included in the software.
Typing the **Place** key allows to display the next location available in the database.
Using ↰ **Place** allows to go in the reverse way, to have the previous location.

For the chosen location, following data is displayed :

- Longitude,
- Latitude,
- Altitude,
- Country,
- Time Zone.

```
Washington
Long.  W °'": 77.04
Lat.   N °'": 38.55
Altitude  m: 92
Country: United States
Time Zone: -5
```

If the chosen location was added by the user (chapter 4.1), country information is replaced with **<Added>**.

Each location in the database is identified by a number (shortly displayed after **Place** is typed). This number is decimal :

- Integer part is the country number.
- Floating part (hundredth) is the city number.

This number allows a quick access to a location, by using parameters.
When you type the **Place** key :

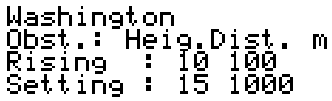
- If there is one parameter in the stack, it is used as the wanted location number.
- If there are two parameters, first one is the location number, and second one is altitude (in meters).

You can also define obstacles (hills, trees), which will be used for rising and setting times computation.
For that, 6 parameters are needed in the stack before you type **Place** :

- Number of the location,
- Altitude (in meters : m),
- Obstacle height on east side (in m),
- Obstacle distance on east side (in m),
- Obstacle height on west side (in m),
- Obstacle distance on west side (in m).

If there is no obstacle on one side, 0 is to be used for height, and -1 for distance.

When obstacles are defined, the formatted display gives location information in first screen, and obstacles parameters in second screen.



See chapter 4.1 to know how to add locations in the database.

3.2.3 Daylight Saving Time **DST**

This menu item allows to set or reset the daylight saving time.
If DST is set, one hour is added to the time zone defined with location.
Example for Western Europe : +1 in winter, and +2 in summer when DST is set.

3.2.4 Language **Engl**

This menu item is used to change the language for menu and results. The current language is shown on the menu item. Three languages are available : French, English and Spanish.

3.2.5 Display **Disp**

This menu item can be used to display again the last formatted results. It is available in all menu lines.

3.2.6 Exit program **End**

This menu item is used to exit from software. It restores the system binary indicators, and go to HOME path.

3.3 Software Parameters (Second line of menu)

HRZ ■ hms■ RTS Per■ Disp

Following parameters allow to choose coordinates system, display mode for results, and perturbations option.

These parameters are stored using one variable and binary indicators, and remain defined for a future use of the software.
Their value is shown in menu item : a square (■) means parameter is set (on), else it is reset (off).
For coordinates systems, unit is degree (angle), except for right ascension, where it is hour.

3.3.1 Coordinates ECLI EQUA HR HRZ HRZN+ HRZ+ HRZN-

According to the menu item, computation is done for the following coordinates :

- **ECLI** : geocentric ecliptic coordinates, longitude (λ) and latitude (β),
- **EQUA** : equatorial coordinates, right ascension (α) and declination (δ),
- **HR** : hour coordinates, hour angle (H) and declination (δ),
- **HRZ** : horizontal coordinates : azimuth (A) and altitude (h, height). Azimuth origin is south, and its direction is clockwise (trigonometric -).
- **HRZN+** : horizontal coordinates : azimuth (an) and altitude (h). Azimuth origin is north and its direction is counterclockwise (trigonometric +),
- **HRZ+** : horizontal coordinates : azimuth (a) and altitude (h). Azimuth origin is south and its direction is counterclockwise,
- **HRZN-** : horizontal coordinates : azimuth (An) and altitude (h). Azimuth origin is north and its direction is clockwise.

3.3.2 Coordinates Format hms

If **hms■** is set, coordinates will be displayed in degrees, minutes and seconds of arc (°'"), else they will be displayed in decimal degrees (°).
For right ascension, are respectively displayed hours, minutes and seconds (hms), and decimal hours (h).

3.3.3 Rising, Transit, Setting RTS

When this parameter is set, the program will compute rising, transit (meridian crossing) and setting times, for the given celestial object.
This computation is quite long (especially for the Moon), so it is advised to reset this parameter if this information is not needed.

3.3.4 Perturbations Per

If this parameter is set, gravitational perturbations are included in computation for position of the 7 planets Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune. With perturbations on, you get more accurate results (especially for giant planets), but computation is longer.

3.4 Ephemeris

Ephemeris are computed and displayed for each object, when corresponding menu item is chosen.
These menu items are displayed in four menu lines :

- the Sun, the Moon, and Earth,
- planets visible to the naked eye (Mercury, Venus, Mars, Jupiter et Saturn),
- far planets (Uranus, Neptune, Pluto), asteroids and comets,
- stars and Messier objects.

Computation results are displayed formatted, on one page, or two if **RTS** is set.

If two pages are available, a sub menu allows to display page 1 (**Page1**), page 2 (**Page2**), or go back to general menu (**Menu**).

For the concerned object, if **RTS** is set, are displayed on page 2 :

- Rising time (hm unit),
- Transit time (hms),
- Setting time (hm).

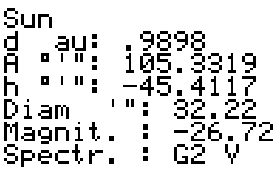
Results are stored, in order to be displayed again without other computation. This is done only for the Sun, the Moon, Earth and planets. When **Init** or **Place** is used, all stored results are cleared.

3.4.1 The Sun

Sun ephemeris are computed at initialization (**Init**), because they are needed for other celestial objects.
The **Sun** menu item only displays them.

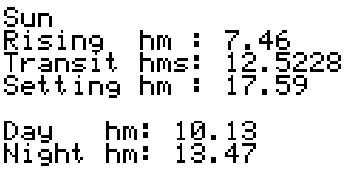
Displayed results are :

- Distance from Earth, in astronomical units (au),
- Coordinates, according to the chosen mode,
- Apparent diameter, in minutes and seconds of arc ('"),
- Relative magnitude,
- Spectral type.



If **RTS** parameter is set, on page 2 :

- Day duration (hm),
- Night duration (hm).

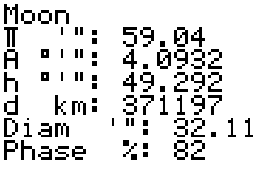


3.4.2 The Moon

Moon computes ephemeris for the Moon.

Displayed results are :

- Parallax, in minutes and seconds of arc ('"),
- Coordinates, according to the chosen mode,
- Distance from Earth, in km,
- Apparent diameter, in minutes and seconds of arc ('"),
- Phase, in percentage of illumination.



On page 2 :

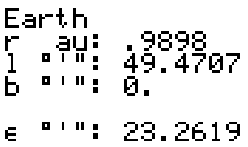
- Age, in days and hours, since new Moon.
- If applicable, « New Moon », « Full Moon », « First Quarter », or « Last Quarter ».

3.4.3 Earth

Earth ephemeris are based on the Sun's.
The Earth item only displays them.

Displayed results are :

- Distance to the Sun, in astronomical units (au),
- Heliocentric ecliptic coordinates : heliocentric longitude (l) and heliocentric latitude (b),
- Inclination of earth equator on ecliptic plane.



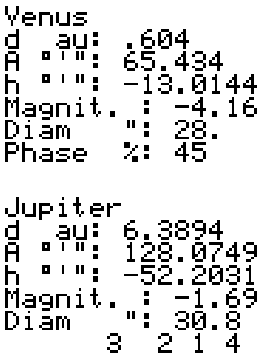
With ↱ Earth, you compute date and time of solstices and equinoxes (seasons).

3.4.4 Planets Merc Venus Mars Jupi Satu Uran Nept Pluto

These keys give ephemeris for Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto.

Displayed results are :

- Distance from Earth, in astronomical units (au),
- Coordinates, according to the chosen mode,
- Relative magnitude,
- Apparent diameter, in seconds of arc (''),
- Phase, in percentage of illumination, for Mercury, Venus and Mars,
- For Jupiter, the 4 Galilean satellites positions.
  Each satellite is displayed using a number (1=Io, 2=Europe, 3=Ganymede, 4=Callisto) and its position on the screen shows the apparent distance to Jupiter supposed to be in the center of the screen. The picture is not reversed (it is as seen with binoculars). If two satellites are in the same place on the screen, they are displayed using '/'. Three in the same place : '+', four : '*'.



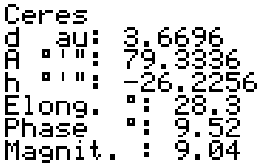
3.4.5 Asteroids Aster

Asteroids orbital data is in a database. Each asteroid has a number, to identify it (same thing than places). This number is shortly displayed each time Aster is typed.

Typing Aster increments the asteroid number, and computes ephemeris for this asteroid.
↰ Aster does the same, but it decrements the number.
If there is a parameter in the stack when Aster is typed, it is used as the wanted asteroid number.

Displayed results are :

- Distance from Earth, in astronomical units (au),
- Coordinates, according to the chosen mode,
- Elongation, in degrees,
- Phase, in degrees,
- Relative magnitude.



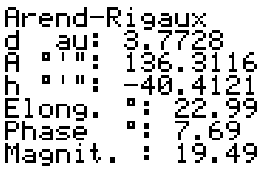
See chapter 4.2 to know how to add asteroids in the database.

3.4.6 Comets Comet

This menu computes ephemeris of a comet, whom orbital elements have been defined by the user.

Displayed results are :

- Distance from Earth, in astronomical units (au),
- Coordinates, according to the chosen mode,
- Elongation, in degrees,
- Phase, in degrees,
- Relative magnitude.



Typing ↱ Comet recalls the list for comet orbital elements in the stack.
This list can be modified and stored with ↰ Comet. These new parameters will be used for ephemeris computation, at the next Comet typing.

This list contains following parameters :

- Name of the comet (string of characters),
- JDperihelie : date for perihelion transit (real number, Julian date),
- e : eccentricity for orbit (real number),
- q : distance from the Sun, when perihelion transit (real number, in astronomical units),
- ω : perihelion latitude argument (real number, in decimal degrees),
- Ω : ascending node longitude (real number, in decimal degrees),
- i : inclination of orbit on the ecliptic plane (real number, in decimal degrees),
- mag : absolute total magnitude (real number).

This data can be found in astronomical publications, as listed in chapter 1.2.

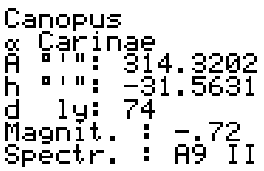
3.4.7 Stars Star

Stars orbital data is in a database. Each star has a number, to identify it (same thing than places and asteroids). This number is shortly displayed each time Star is typed.

Typing Star increments the star number, and computes ephemeris for this star.
↰ Star does the same, but it decrements the number.
If there is a parameter in the stack when Star is typed, it is used as the wanted star number.

Displayed results are :

- Common name,
- Name (Greek letter + constellation Latin name's genitive),
- Coordinates, according to the chosen mode,
- Distance from Earth, in light years (ly),
- Relative magnitude,
- Spectral type.



See chapter 4.3 to know how to add new stars in the database.

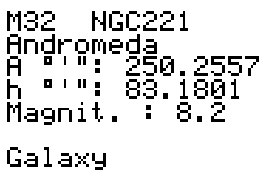
3.4.8 Messier Objects Mess

Messier objects orbital data is in a database. Each object has a number, to identify it (same thing than before). This number is shortly displayed each time Mess is typed.

Typing Mess increments the object number, and computes the ephemeris for this object.
↰ Mess does the same, but it decrements the number.
If there is a parameter in the stack when Mess is typed, it is used as the wanted object number.

Displayed results are :

- Number in the Messier catalog (Mnnn) and number in the New General Catalog (NGCnnnn),
- Name of the constellation where the object is,
- Coordinates, according to the chosen mode,
- Relative magnitude,
- Object type (Galaxy, Open Cluster, Globular Cluster, Planetary Nebula, Gas Nebula).



See chapter 4.4 to know how to add deep sky objects in the database.

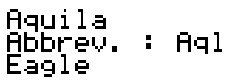
3.4.9 Constellations Const

This menu reminds to you usual name, Latin name and abbreviations of the 88 constellations.
Constellations is are in a database. Each constellation has a number, to identify it (same thing than before). This number is shortly displayed each time Const is typed.

Typing Const increments the constellation number, and displays information about this constellation.
↰ Const does the same, but it decrements the number.
If there is a parameter in the stack when Const is typed, it is used as the wanted constellation number.

Displayed results are :

- Latin name,
- Standard abbreviation,
- Common name.



4 Database Modification

This chapter describes the databases for places, stars, Messier objects, and asteroids.

Each database is a list of lists, stored in a variable, in EPHE directory.
This list has as many elements as there are objects defined.

Additional databases are empty after initialization. At this time, only the internal databases are available.

By editing the places list, you can add new places, with respect to parameters meaning and position. Same thing for stars, Messier objects, and asteroids.

4.1 Places

The list of locations is stored in : 'LieuxS' (characters case is important).
The list of places is a list of lists. It contains one list per defined place.

For each place, this list has 5 elements :

- Name of the place (string of characters),
- Longitude (real number, in sexagesimal degrees : °.'"), positive for West, negative for East,
- Latitude (real number, in sexagesimal degrees : °.'"), positive for North, negative for South,
- Time Zone (real number), positive if longitude is at East of Greenwich,
- Altitude (real number, in meter).

Example :

{{ "Paris" -2.2015 48.5011 1 67 }}

It is advised to sort added Places alphabetically.

4.2 Asteroids

The list of asteroids is stored in : 'AsteroidesS' (characters case is important).
The list of asteroids is a list of lists. It contains one list per defined asteroid.

For each asteroid, this list has 9 elements :

- Name of the asteroid (string of characters),
- Time for perihelion transit (real number, Julian date),
- Eccentricity for orbit (real number),
- Half large axis for orbit (real number, in astronomical units),
- Perihelion latitude argument (real number, in decimal degrees),
- Ascending node longitude (real number, in decimal degrees),
- Inclination of orbit on ecliptic plane (real number, in decimal degrees),
- Absolute magnitude (real number),
- Slope parameter (real number), used for the magnitude computation.

Example :

{{ "Ceres" 2451515.81363 .0778806 2.7662043 73.79376 80.50188 10.58289 3.3 .12 }}

4.3 Stars

The list of stars is stored in : 'EtoilesS' (characters case is important).
The list of stars is a list of lists. It contains one list per defined star.

For each star, this list has 8 elements :

- Usual name of the star (string of characters),
- Greek letter of the name (character),
- Constellation number (integer),
- Right ascension (real number, in sexagesimal hours : hh.mmss),
- Declination (real number, in sexagesimal degrees : °.'"),
- Relative magnitude (real number),
- Distance (real number, in light years),
- Spectral type (string of characters).

Example :

{{ "Sirius" α 14 6.44583 -16.4238 -1.46 8.6 "A0m A1 Va" }}

4.4 Messier Objects

The list of Messier objects is stored in : 'MessierS' (characters case is important).
The list of objects is a list of lists. It contains one list per defined object.

For each object, this list has 8 elements :

- Number in the Messier Catalog (integer),
- Number in the New General Catalog (integer),
- Constellation number (integer),
- Right ascension (real number, in sexagesimal hours : hh.mmss),
- Declination (real number, in sexagesimal degrees : °.'"),
- Relative magnitude (real number),
- Object type (integer : 1=Galaxy, 2=Open Cluster, 3=Globular Cluster, 4=Planetary Nebula, 5=Gas Nebula).

Example :

{{ 1 1952 78 5.35 22.01 8.4 4 }}

5 How to Contact the Author

Jean Philippe EIMER
email : phil.eimer@9online.fr
WWW : http://phileimer.9online.fr

6 Change Log

- 2.13 – 09/2007 : corrections - Julian date (thanks to Bill), M51, Moon's age - and location initialization after installation.
- 2.12 – 01/2006 : system date format is now used.
- 2.11 – 12/2005 : dramatic improvement in computation speed (thanks to Khanh-Dang), better management of indicators (save/restore).
- 2.10 – 11/2005 : places database now contains countries, and place index is a decimal number, English document is now PDF.
- 2.02 – 08/2005 : two horizontal coordinates modes were added (HRZN- and HRZ+).
- 2.01 – 06/2005 : support of HP49G+ ROM version 2.0 (larger screen).
- 2.00 – 05/2005 : adapted to HP49/HP49G+, HP48 is no longer supported in version 2. A Spanish translation was added.
- 1.33 – 01/2005 : email change.
- 1.32 – 05/2001 : added horizontal coordinates with north as azimuth origin (HRZN).
- 1.31 – 07/2000 : saved results are emptied if coordinate selection is modified.
- 1.30 – 04/2000 : computation results are now saved (see chapter 3.4).
- 1.22 – 01/2000 : added solstices and equinoxes (seasons) date and time computation (see chapter 3.4.3).
- 1.21 – 12/1999 : this document converted to HTML.
- 1.20 – 05/1999 : modification of the coordinates selection, hour coordinates added, several cities added, update of this document.
- 1.11 – 10/1998 : correction of a data displaying bug : when there's no rising/setting, a dash is displayed for the time, instead of a number.
- 1.10 – 04/1998 : new time zones included in locations database, daylight saving time added, rising, setting and meridian crossing times displayed in local time instead of UT, update of this document.
- 1.01 1.02 1.03 1.04 1.05 – 03/1998 : data and algorithms corrections, cities added in locations database.
- 1.00 – 01/1998 : initial version of EPHE and this document.