XEphem™

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The Scientific-Grade Interactive Cross-Platform

Astronomical Software Ephemeris

UNIX – Mac OS X – MS Windows

Version 3.5.2 User Manual

Clear
Sky
Institute

Contents

1 XEphem -- the Interactive Ephemeris

Thank you for using XEphem.

XEphem is an interactive astronomical ephemeris program. *XEphem* provides a rich set of accurate astrometric calculations and attractive graphical and image displays in an easy-to-use GUI framework. XEphem includes extensive on-line context-sensitive help, examples, and bubble tips on all controls.

1.1 Summary of Capabilities

XEphem ...

is a scientific-grade interactive astronomical ephemeris package;

computes heliocentric, geocentric and topocentric information for all objects;

has built-in support for all planets; the moons of Mars, Jupiter, Saturn, Uranus and Earth; central meridian longitude of Mars and Jupiter; Saturn's rings; and Jupiter's Great Red Spot.

allows user-defined objects including stars, deepsky objects, asteroids, comets and Earth satellites.

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offers many large databases including Tycho, Hipparcos, GSC, USNO.

displays data in configurable tabular formats in conjunction with several interactive graphical views;

graphically displays a 24 hour period showing when any selected objects are up;

displays 3-D stereo views of the Solar System that are particularly well suited for visualizing comet trajectories;

quickly finds all close pairs of objects in the sky;

sorts and prints all catalogs with very flexible criteria for creating custom observing lists;

can create plots of any pairs of all data fields throughout the program;

downloads AAVSO light curves directly online;

downloads current asteroid and comets lists from Lowell and MPC;

downloads timely Earth satellite orbital TLE parameters;

downloads Digitized Sky Survey FITS files from STScI or ESO;

displays seti@home client progress and plots position being processed on Sky View map;

provides a handy spreadsheet for converting among equatorial, ecliptic, horizontal and galactic coordinates;

includes a compiler for entering and solving user-written functions using any data fields;

serves as the control point for GOTO telescopes in real-time such as Meade LX200;

displays FITS files and DSS images overlaid with properly registered database symbols and other graphical information;

performs automatic star pattern matching to solve for accurate World Coordinate System on any image;

performs 1-click 2D Gaussian relative and absolute photometry;

lets you define and save any number of Eyepieces to use in sky maps;

displays your own local horizon profile;

can store sets of Sky View options for easy playback later;

uses high quality Postscript for all printing.

XEphem can compute information on demand or time can be set to increment automatically. In this way a series of computations and movies can be generated.
Plot and listing files of selected field values may be generated as the program runs. The plot files are full precision floating point values in ASCII intended for export to other plotting programs or XEphem includes its own quick-look plotting facilities. The listing files are tables formatted for more general human reading.

Quantitative information available about each object includes:

RA and Dec,
local azimuth and altitude,
distance from sun and earth,
light travel times,
heliocentric coordinates,
galactic coordinates,
ecliptic coordinates,
solar elongation,
angular size,
visual magnitude,
illumination percentage,
local rise and set times and azimuths,
local transit times and altitude,
length of time up,
constellation,
angular separations between all combinations of objects.

Local observing circumstance information includes

UTC and local date and time,
local sidereal time,
times astronomical twilight and length of night,
local temperature and pressure (for refraction),
elevation above sea level (for parallax),
a monthly calendar.

RA/Dec calculations may be topocentric or geocentric, and apparent or astrometric. When the Equinox is set to a fixed date the values are astrometric, that is, corrected only for precession and light travel time. When the Equinox is set for EOD (Equinox of Date) the values are apparent and are also corrected for nutation, aberration and relativistic deflection. Topocentric values are further corrected for parallax, augmentation and refraction.

XEphem can read databases of objects (§13). The objects may be fixed; specified via heliocentric elliptical, hyperbolic or parabolic orbital elements to accommodate solar system objects such as asteroids or comets; or specified via geocentric elliptical orbital elements to accommodate Earth satellites. These are then available as candidate values for the user defined objects and all of them can be displayed in the sky map subject to type and magnitude filters. The format of the database file is described in the Help for the DB window.

1.2 UNIX Installation

To install from the CDROM you just basically mount it and run the **install** script. You must be *root* to perform the installation because several files are placed in system directories. Also, check the **README** for any last minute instructions.

Accessing the CDROM drive is the first step. For example, on Red Hat Linux the following is typical:

```
$ su
Password: ********
# mount /mnt/cdrom
# /mnt/cdrom/install
...
```

Some systems use just `/cdrom`.

Once you can access the CDROM run the `install` script:

```
# /mnt/cdrom/install
  ...
```

In rare cases your system may have been configured to prevent execution of programs directly from the CDROM. If this happens the above will complain immediately and exit. The solution is to copy the script to some place on the hard drive and run it from there. For example:

```
# cp /mnt/cdrom/install /tmp
# chmod u+x /tmp/install
# /tmp/install /mnt/cdrom
  ...
```

Note that in this scenario you should run `install` with one argument: the full path to the CDROM.

You will now be asked a short series of questions. As appropriate, each question may be followed by the possible responses in parentheses and a default in square brackets that is used if you just type Enter. For example:

```
Proceed to install XEphem Version 3.4? (y/n) [y]
```

The possible responses are to type **y** or **n** followed by Enter; Enter alone will be the same as **y**.

Follows is some commentary on the various questions asked by the install script in the order in which they appear.

1)   You are asked to confirm you really do want to install XEphem and, if so, are asked to agree to its licensing terms. Answering **n** to either of these will end the installation with no change to your system.

2)   You are asked to specify several directories. In most cases the defaults offered should work fine. However, in deference to local customs, the installation allows you to change them if desired. Basically if you do not know the significance of a directory, take the default.

        Application defaults: a very small file will be created here so *xephem* can know your choice for the Base Installation directory (see next).

        Base installation: this will contain all the supporting files needed by *xephem* at runtime, including all the catalogs. This must have at least 200MB free for a basic installation, or 800MB if you choose to also install the USNO catalog (described shortly). All files in this directory are used read-only by XEphem and can be shared among all users.

        If you have installed XEphem before and you elect to use the same Base directory, some files will be added and many files will be overwritten. The install script makes no attempt to clean out deprecated files or preserve files that are being updated. It is recommended that you keep any special work you may have done in this directory then remove it, letting the install script create a fresh directory.

        Manual page: the directory where the XEphem manual page will be placed. It is written for chapter 1X.

        Executables: the directory where the *xephem* program itself will be placed, and a few other supporting programs.

        Private: each user of XEphem can have a directory for their private files. An initial sample is set up in this directory.

3)   The Base Installation directory requires about 200MB. If there is not that much on the specified directory the script will now exit.

4)   Next you must indicate your operating system and architecture. If you chose one from those listed the proper executable files will be copied to the Executables directory. If you elect to not specify, all supporting files will be copied but you will not have the *xephem* program itself. In this case, some hints on how to proceed are in the README on the CDROM.

5)   Next you will be asked if you want to load the USNO SA2.0 catalog. This requires an additional 600MB in the Base Installation directory. You are not asked if this directory does not contain this much room. You may not want this catalog, even if you have room. It is a list of about 55 million stars specially chosen to be roughly evenly spaced on a grid

Page 1-4   **Version 3.5.2**

around the entire sky for use as astrometric reference points. The stars were chosen for their proximity to this grid, not for their magnitude. Indeed, most bright stars are not in this catalog at all, but it does contain some stars down to as dim as 20th magnitude. The result is that the catalog is very useful if you want to perform careful positional measurements on images but is otherwise not interesting for general use because it does not *look* at all like the real sky.

That's all the questions. Now the real work begins. As the script proceeds it creates a list of all files created on your system during installation in the file `/tmp/XEphem-3.4.log`. The basic activities are as follows:

create a default resource file in Application Defaults.
create an initial empty Private directory.
create a file *.xephemrc* in your home directory pointing to your Private directory.
copy the appropriate binaries to the Executables directory.
copy the man page to the Manual page directory.
copy all the files needed to the Base Installation directory. This will take most of the install
    time and a running progress percentage will help you judge when it will finish.
if the USNO catalog was chosen, a background process is now started to decompress it.
create the fifos needed for telescope control.

If all goes well, when the install script completes, you may run XEphem.

1.2.1 Launching XEphem

XEphem supports the following command line arguments:

```
 -env N=V  : set alternate env Name=Value
 -help                  : print this message then exit
 -install {yes|no|guess}  : whether to install a private colormap
 -prfb                  : print all fallback resources then exit
 -resfile f             : load alternate resource file, f
```

When XEphem is launched it looks for a file named .xephemrc in the $HOME directory. This file is optional. If it exists, it should contain a line with the following form:

   XEphem.PrivateDir: ~/.xephem

The directory named on the right is where XEphem will create and use per-user, or "Private" files. A leading "~" in the file name can be used to refer to $HOME, your login directory. The example above causes the Private directory to be .xephem in the users $HOME directory. If .xephemrc does not exist or does not contain this line the default Private directory is ~/XEphem. The private directory will be created if it does not already exist.

XEphem then also searches for another directory. This one can be shared among all XEphem users on a system. Files in this directory are never modified by XEphem. They include databases of objects, supporting images and other files. This directory is specified in a resource file named "XEphem", itself located within the Private directory (see above). It should contain a line with the following form:

   XEphem.ShareDir: /usr/local/xephem

The directory named on the right is where XEphem will look for all "Shared" files. A leading "~" in the file name can be used to refer to $HOME.

Next XEphem sets the initial values of most options and settings from other entries in the resource file. Settings which do not appear will use their internal default values.

1.3 Windows Installation

Executive summary:

1. run **setup.exe**, taking all default values
2. reboot
3. double-click the new **XEphem** shortcut on the desktop

Long version:

XEphem must be installed by the Administrator (or a user account in the Administrators group). After installation, if desired, it is possible to allow multiple users to run XEphem so they each have their own separate workspaces while sharing the large support files and databases. Details of sharing are be described in §1.3.3 .

Insert the CDROM and your computer should start the installation program automatically. If it does not, run the **setup.exe** program by clicking **Start** → **Run**, then type

```
d:\setup.exe
```

Change the letter "d" to whichever device Windows considers your CDROM drive.

The installation takes a while because of all the data being copied. It also behaves a little unusual compared to most Windows programs. One reason for the complexity is that really three programs are being installed. XEphem is written for UNIX. In order to run on Windows it requires a porting layer. We have chosen the outstanding **MKS** Toolkit for Enterprise Developers (see http://www.mkssoftware.com). Also required is an X Windows Server. We have chosen the MI/X server from **Microimages** (see http://www.microimages.com). If you already happen to have an X Windows server on your system there is a small chance of a conflict. To reduce this further, XEphem and MI/X are set to use display :1. This can be changed to display N for XEphem by editing the Target Property of the desktop and Start shortcuts to `-display :N`, and for MI/X by changing the Network Port number preference to 6000+N. If all this means nothing to you, consider yourself lucky.

The installation will insure you select a disk with the required amount of free space. After installing the MI/X server you will get an instance of Explorer showing the files it installed which you can just dismiss. The final step is to reboot. When your computer comes back up, you will find a new shortcut for XEphem on your desktop and in the **Start** menu under **Programs** → **Clear Sky Institute Inc**.

1.3.1 Starting XEphem the First Time

Start XEphem by double-clicking on the XEphem desktop shortcut. You will see an Authorization dialog. Ignore what it says about buying a license from Microimages. That was already included in your XEphem purchase. For now you can just click on Ignore. However, within 15 days you must obtain a valid authorization code from us. There is no charge for this code but you do have to send us an email to get it. To obtain your code, send the machine ID *exactly as it appears* as the only thing in the *body* of an email and send to:

xewinregister@clearskyinstitute.com.

The Subject of the email will be ignored. You will receive a reply back to the address from which your ID was sent containing an Authorization Code before your gratis period expires. The machine ID depends on your hardware and the code will only work on that one computer system. Once you enter a valid code, you will no longer see this dialog.

After clicking through the Authorization window you will see a large black window, a small **Workspace Overview** window (explained shortly), then after a short while XEphem's Main window. If you took more than a few moments to ponder the Authorization window then XEphem probably gave up waiting and you will just have a black window forever. If so, just close the workspace (click on the × in the upper right like you would close any Windows app) and start XEphem again, this time clicking Ignore right way. See the rest of this manual for using XEphem.

The Overview window allows you to control the MI/X workspace that is, in effect, larger than your screen and completely dedicated to XEphem's windows. You will find this very handy because XEphem has many windows which you may want open at the same time and this gives a handy way to manage them all.

The Overview window represents the entire workspace in miniature. The red box represents the portion of the workspace currently visible. You can move this visible space around by clicking inside the red box and dragging it around or by using the scroll bars on the right and bottom edges of the screen. Also in the Overview window is one little gray rectangle representing each XEphem window that is currently open on the workspace. When you first start XEphem, only the Main window is up so you see one such rectangle. To move this rectangle around on the workspace, as well as the real XEphem window which it represents, press Shift then click on the rectangle and drag it around. The Overview window itself may also be moved in the usual manner by clicking in its title bar and dragging it around. Note that it always remains in the same place relative to the *screen*, not the workspace. You can learn even more about the Overview window by clicking on the **?** in its upper right corner.

The workspace and all its XEphem contents appears as one entry on the Windows Taskbar. The taskbar will read **MicroImages X Server** but you can think of it as the XEphem workspace. You will *not* see the individual XEphem windows on the Windows taskbar. The entire XEphem workspace may be minimized by clicking on the usual symbol in the upper right corner of the workspace.

In the upper right of each XEphem window is a small × which will close that window within the MI/X workspace. When the main XEphem window is closed, the entire workspace is also closed. To resize a window, click on the edge and drag as desired.

With a bit of practice, this is actually all quite useful and expedient. Please give it a little time.

1.3.2 File Structure

In this section we describe the disk file structure that has been created for XEphem. This information is not necessary for typical operation so you may skip this for now and come back some day if you are curious.

If XEphem is installed in the default location, the following directory structure is created:

```
c:\Program Files\Clear Sky Institute Inc\
        nutc\
                bin\
                auxil\
                catalogs\
                fifos\
                fits\
        XEphem\
```

XEphem contains files specific to each user such as preferences, plots and lists. Initially it contains one file, XEphem, a file containing a few default values different from those built within the program. If a change is made and saved as a new Preference setting, it is recorded in this file.

Nutc contains all files that can be shared among all users. Some of these are described below.

bin contains the binary executable files for XEphem itself and some auxiliary command line tools such as the driver for using XEphem with LX200-compatable telescopes and programs for updating the asteroid databases. The installation process adds this directory to global PATH. Later in the XEphem documentation where it refers to the **tools** directory it really means **bin** in the Windows version.

auxil contains supporting files such as planetary images, observing sites, help text and certain ephemeris data.

catalogs contains object databases in XEphem's .edb, .xe2 and .gch formats. The Hubble Guide Star catalog is in **catalogs\gsc** and the USNO SA2.0, if installed, is in **catalogs\usno**. If USNO was not installed initialled just copy it here later when you decided you want to use it.

fifos is used for communication between XEphem and the LX200 driver.

fits can be used to store image files in FITS format.

1.3.3 Multiple Users

The shortcut installed on the Windows desktop and in the Start menu under Clear Sky Institute define the paths to the Nutc and XEphem directories for the current user. If your installation is to support multiple user accounts, they should all point to the same Nutc directory but to individual XEphem directories. To see how these are set up, right-click on the desktop shortcut for XEphem and select the Properties menu entry. The two fields of interest are Target and Start in.

Target specifies the full path to the xephem.exe executable, followed by an argument which specifies the full path to the private directory to be used by one user. It is this second argument that should be made unique for each user. For example:

```
"c:\program files\clear sky institute inc\nutc\bin\xephem.exe" -env "HOME=c:\program
files\clear sky institute inc"
```

Start in specifies the full path to the shared directory which can be used by all users. XEphem does not change the files in or below this directory. For example:

```
"c:\program files\clear sky institute inc\nutc"
```

The icon for XEphem is

```
c:\program files\clear sky institute inc\nutc\bin\xephem.ico
```

1.3.4 File naming

File names in XEphem will appear somewhat different than they normally do under Windows. Drive letters are changed from x: to /x=/ and backslashes are changed to forward slashes. So for example, the following file name in normal Windows:

```
c:\program files\clear sky institute inc\nutc\auxil
```

will appear as follows inside XEphem:

```
/c=/program files/clear sky institute inc/nutc/auxil
```

This only refers to places where XEphem *displays* a file name. In most cases throughout XEphem where you are asked to *enter* a path name, you may use either naming strategy.

1.3.5 Printing

XEphem performs all printing using high quality Postscript format but printers typically found on Windows computers do not directly support this format. We could have included a nice commercial Postscript printing package on the XEphem distribution and passed the licensing cost on to you. Instead, we noted that same package can be downloaded off the Internet at no charge for personal use. So you save money by performing the installation yourself as follows:

> 1. Go to **http://www.ghostscript.com**. Look for and go to the link at **wisc.edu**. Download the latest release of AFTL Ghostscript (not GNU Ghostscript). You do *not* need ghost*view*, just ghost*script*. As of this writing the latest version is 7.00 located at ftp://mirror.cs.wisc.edu/pub/mirrors/ghost/AFPL/gs700/gs700w32.exe. This is known to work well with XEphem.
>
> 2. Install ghostscript according to its instructions. Basically just run the .exe. Be sure the option to **Install fonts** is checked. Note the installation directory. For the purposes of this discussion we assume you install at c:\gs.
>
> 3. Bring up any XEphem Print dialog. For example, from the Main window click **Views** → **Sky View** then click **Control** → **Print**. Check the **Print command** and make sure it appears exactly as follows (*case is significant*):
>
> > ```
> > /c=/gs/gs7.00/bin/gswin32c.exe  -sDEVICE=mswinpr2
> > ```
>
> If the version has changed from 7.00 or if you installed ghostscript some place other than c:\gs then change this part of the command accordingly. If the Print Command is already correct, you are finished. If you had to edit it, there is one more step:
>
> 4. Back in the XEphem Main window, click **Preferences** → **Save** and click on the **Save** button at the bottom. This will make the change to the Print Command permanent for this user.

Now when you Print from XEphem, ghostscript creates a normal Windows print job which you manage like any other. We find this print window is sometimes buried beneath the XEphem workspace, so you may have to find it on the Windows Taskbar and bring it to the front before you can use it.

1.3.6 Uninstallation

To completely remove XEphem and all its supporting components click on **Start → Settings →
Control Panel**. Then double-click on and open **Add/Remove Programs**. Remove the following
programs in order:

```
MKS Platform components 7.x
Microimages X Server
XEphem
```

If you have installed ghostscript for printing, then also remove these two programs:

```
AFPL Ghostscript 7.00
AFPL Ghostscript Fonts
```

During these uninstalls, a few files will not be successfully removed for various reasons. This is
normal. After running each uninstall as above, use Windows Explorer to remove the directory in
which XEphem was originally installed; the default was `"c:\program files\clear sky
institute inc"`. Similarly, remove the X server directory, the default for which was
`"c:\program files\microimages"`. This will catch these few stray files and XEphem and
its helpers will be completely gone.

1.4 Apple Mac OS X Installation

Details arrived too late to be including in the first printing. Please see the appendix.

1.4.1 LX200

Apple computers usually have USB ports, not serial ports. To operate an LX200 with its serial
port we suggest the USB-Serial adaptors made by Keyspan (see http://www.keyspan.com). You
will need an adaptor, such as the model USA-18x (one port) or USA-28x (two ports), and their
driver software for Mac OS X. Only one serial port is necessary for the LX200 but an extra might
be handy for other things. Follow Keyspan's installation directions.

After a successful installion, the serial devices will be available in `/dev`, for example
`/dev/cu.KeyUSA28X9131`. The exact name for your LX200 connection will vary depending on
your USB configuration. Whatever it is, inform XEphem as follows:

1. From the Main XEphem window open **Views -> Sky View -> Telescope -> Configure**

2. Edit the field Serial Device so it contains your appropriate name.

3. Now again from Main, open **Preferences -> Save** and click on Save.

That's it. The chapter on LX200 now applies (see §16).

1.5 Operation

XEphem starts by showing the Main window with each parameter set to its default value. The
parameters on the Main window are primarily devoted to describing the location and time for
which all other data in XEphem are computed. You can change this time manually and press
Update, and all other windows throughout XEphem will be recomputed. Or you can start a loop
that steps time each step automatically by an amount you specify.

There are three fields that control this looping behavior.

Step   is the amount of time to add each step or after one Update

      N Steps   is the number of steps to run in a loop
      Pause   is the amount of real seconds to pause between steps.

When looping is in effect, the bottom button on the Main window says "Stop". When the number of steps goes to 0 or the "Stop" button is selected, the looping stops and the button label changes back to "Update".

A common mode is to have XEphem automatically stay in sync with the computer clock. This can be done as follows:

    set Step to "RT Clock"
    set N Steps to a large number, say, 1000000
    set Pause to the desired update time, say, 10 seconds
    click "Now" under the calendar
    click Update to start running

This is so common in fact the handy shortcut button to the right of the "Looping" title labeled "Now" performs exactly these steps. The value set for Pause will be used unless it is 0 in which case XEphem sets it to 10 seconds.

Speaking of shortcuts, the -1 and +1 buttons to the left of the Looping label each subtract or add to time by one Step, regardless of the setting for N Steps. The value of N is updated accordingly. These two actions can also be performed from the keyboard by typing Control-b ("backward") and Control-f ("forward").

Note that when looping with Pause set to 0, most numeric field data are not drawn in order to speed up the display. These values are always updated internally, however. and may safely be used for plotting, solving or listing. This is true even if the window that displays the information is closed.

Most fields on the Main window may be changed by clicking them. A prompt window with a brief explanation of the field will appear. A new value may be typed into the text field provided. If "Ok" is clicked the new value will be used; if "Cancel" is clicked the field will be left unchanged. In either case, the prompt window goes away. Some of the windows have an extra button which offers a handy way to enter frequently used values for the field.

If you change a field on the Main window that would invalidate any of the other fields in any XEphem window the message NEW CIRCUMSTANCES flashes near the top of the Main window. This will continue until the next Update occurs. If you change any field that causes new circumstances, the "Step" value is not added to the current time before the next loop.

Some graphical views have a push button marked **Movie Demo**. This is a convenient way to start and stop a sample movie sequence. If *XEphem* is currently idle then pushing the button will set the Main window Step to a value that will yield a pleasing motion effect and start looping with a very large number of steps. If *XEphem* is already looping then pushing the button will cause it to stop and set Main window N Steps to 1. The Main window Stop control can also stop the looping in the usual way.

1.6 Triad Formats

XEphem uses many values that get entered in some variation of the form A/B/C, such as date, time, longitude and step size. XEphem calls this a "triad"

Times and RA are entered and displayed in h:m:s format. If you pick such a time field to change it, any of the h, m, and s components that are not specified are left unchanged from their current value. For example, 0:5:0 set hours to 0, minutes to 5, seconds to 0, whereas :5 sets minutes to

5 but leaves hours and seconds unchanged. A negative time is indicated by a minus sign (-) anywhere before the first digit.

Dates are entered and displayed in any one of month/day/year, year/month/day or day/month/year form. A Preference selection on the Main menubar, and controlled by the XEphem resource DateFormat, selects which form is currently being used.

As with time, components omitted when entering a new date retain the current value. For example, if the current date is 10/20/1988 and you type 20/30 the new date will become 20/30/1988. If you then type //2000 the new date will become 20/30/2000. Note you must type the full year since the program is accurate over several centuries either side of 1900.

If you change the date, the time (i.e., partial day) will not change.

Negative years indicate BC dates. For example, Jan 1, 1 BC is given as 1/1/-1. There is no year 0.

Two other ways to set the date are supported for compatibility with some published comet ephemerides. You may enter the day portion as a floating point number. When you set the day this way, the time will also change to correspond to the fractional portion of the day. For example, noon on Jan 2, 1995, may be entered as 1/2.5/1995.

You may also enter a date as a decimal year, as in 1990.12345. Also, when the date format preference is set to M/D/Y or D/M/Y the decimal point may be omitted if the value is not a reasonable month or date value, respectively. Decimal years are useful in interpreting plot files that include a date field, since date fields are stored in plot files as decimal years. Any input that includes exactly one decimal point is assumed to be a decimal year.

Other parameters such as declination, azimuth, altitude, longitude, latitude and "Step" are entered and displayed in d:m:s format and also fall into the general triad format. The same rules apply to these with respect to only having to set the portions that are being changed and the typing conveniences.

For typing convenience, the slash (/) and colon (:) used in any field may also be entered as a hyphen (-), semicolon (;) or comma (,). (Yes, "1-1--1" works for 1 BC.)

2 Main Window
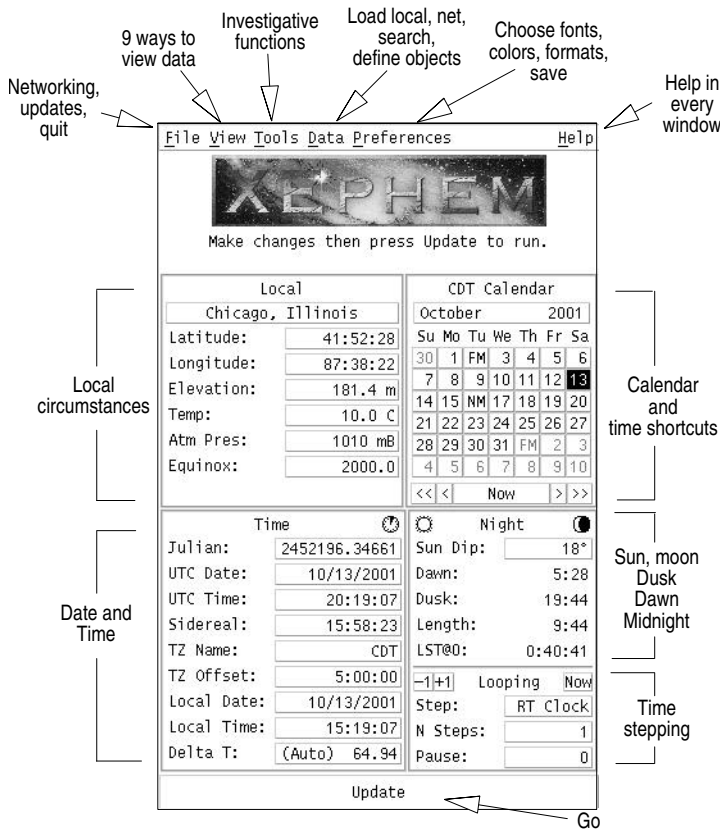
This describes the features of the Main XEphem window.

Across the top is a menu bar to allow selecting the principle functions of XEphem. Each window opened from the menu bar has its own Help. Only a few specific entries will be mentioned here.

Help -> on Context turns the cursor into a Question Mark. Roaming the cursor over any control in XEphem will show its bubble help tip. Press the left mouse button to end this behavior and resume normal operation.

Help -> Search... allows you to search the entire Help database for keywords. Each matching entry will be displayed highlighted in context, and the search may be easily repeated to look for additional occurrences.

Below the main menu bar is the XEphem logo image. Beneath that is a status line that contains a short description of what XEphem is doing at the moment with regards to its looping behavior (see Help -> on Operation).

Below the status line is room for the NEW CIRCUMSTANCES message. When you change any field on the Main window that could invalidate any of the other fields or views throughout XEphem this message flashes until at least one screen Update occurs to get everything up to date again.

See Help -> on Operation (§1.5) for more information on changing the fields in the Main window and controlling XEphem's run time behavior. See the Help -> on Triad formats (§1.6) for more information on date, time and coordinate formats.

Follows is a description of each of the display fields in the Main window.

Local

[Site name]   See below.

Latitude   Local geocentric latitude, positive degrees north of equator. Changing this will disable automatic computation of Daylight Savings Time.

Longitude   Local longitude, positive degrees west of Greenwich meridian. Changing this will disable automatic computation of Daylight Savings Time. A sensible Timezone is created based on one hour for each 15 degrees from 0.

Elevation   Local elevation of the ground above sea level, in feet or meters. (see implementation notes). Used in topocentric parallax correction.

Temperature   Local surface air temperature, in degrees F. Used in refraction correction.

Atm Pressure   Local surface air pressure, in inches of mercury. Used in refraction correction.

Equinox   When set to a year, this is the desired epoch to which the RA/Dec fields are precessed, referred to as the astrometric place. When this is set to EOD, all RA/Dec values are precessed to the current XEphem time, and corrected for nutation, aberration and deflection, referred to as the apparent place.

Time

UTC Date   The UTC date. UTC is "Coordinated Universal Time", the basis, after adjusting for time zones, for the official "civil" time people set their clocks to. Every year or so it is adjusted via a "leap second" so it stays within 0.9 seconds of "UT1", which varies continuously with the slight irregularities of the rotational motion of the Earth.

UTC Time   The UTC time.

Julian   The current Julian date, to about 1-second accuracy.

Sidereal   The apparent sidereal time for the current time and location.

TZ Name   The local time zone name. The name may be fixed to any short mnemonic. Setting this manually turns off automatic computation of Daylight Savings Time. When auto DST is on, a small clock is shown at the top right of the Time section.

TZ Offset   Hours local time is behind UTC, i.e., positive west or negative east of Greenwich. Setting this manually turns off automatic computation of Daylight Savings Time.

Local Date   The local date. This is UTC minus the value of TZ Offset.

Local Time   The local time. This is UTC minus the value of TZ Offset.

Delta T   TT-UT1. Number of seconds by which Terrestrial Time (aka Ephemeris Time prior to 1982) leads UT1. TT is generally of interest when calculating the positions of solar system objects because it is a continuous time scale unaffected by the Earth's rotational vagaries. The term "Terrestrial" means it is adjusted for the relativistic effects of gravity and the Earth's revolution around the Sun. UT1 or UTC is of interest when relating those positions to the horizon to produce altitudes and azimuths. The value may be computed automatically based on the current time or entered manually (in which case it will not change). The algorithm uses values tabulated in the Astronomical Almanac for years 1620.0 through 1998.0, and is accurate to within a few seconds over that interval. Dates prior are

from Stephenson and Morrison or K. M. Borkowski, with an estimated error of 15 minutes at 1500 B.C. A linear extrapolation formula predicts future values.

Night

Sun Dip   The number of degrees the Sun is below the horizon that we wish to call twilight. Common definitions include: Civil = Sun 6 degrees down (headlights barely show on pavement), Nautical = Sun is 12 degrees down (sky and ocean merge), Astronomical = Sun is 18 degrees down (dark as it gets). The Sun Dip setting applies to the following fields:

Dawn   Local or UTC time when the Sun center is "Sun dip" degrees below the horizon before sunrise today.

Dusk   Local or UTC time when the Sun center is "Sun dip" degrees below the horizon after sunset today.

Length   Length of astronomical night, i.e., Dawn - Dusk. If this and the display for Dawn and Dusk are shown as "-----", it means the Sun is either always below or always above "Sun dip" degrees below the horizon on this particular day. N.B. These three fields always apply to the local current day. Difficulties arise when these events occur within 4 minutes of local "midnight" with respect to the time zone defined by TZ Offset. In particular, if these fields are not behaving as you would expect, check that the TZ Offset is set commensurate with the current Longitude.

LST@0   Local Sidereal Time at next local Midnight, as per the time zone.

Looping (see also §1.5)

-1 +1   These are shortcuts to go backwards or forwards by one Step. Can also be performed by typing Control-b and Control-f.

Now   Clicking this button will synchronize XEphem to the computer clock and commence Updating every Pause seconds. If Pause is 0 when this is started, it will be set to 10 seconds. This is really just a shortcut to clicking Now under the calendar; setting Step to RT Clock; N Steps to something large and then clicking Update.

Step   The amount of time UTC (and its derivatives) is incremented each loop.

N Steps   The number of times the display will be updated (time advanced by Step each step) automatically.

Pause   Number of seconds to pause between screen updates. This is used mainly to set up for free-running unattended operation. Pausing is not done when plotting or solving is active. When looping, time is maintained at a whole multiple of pause length.

Site name:

Above the Latitude field is an button which can display the current site name. Pressing this button will bring up a list of cities and observatories. The list is from the file named "xephem.sit" in the shared directory. Click on one entry in the list then press Set to set the Name, Latitude, Longitude, Elevation and Time Zone fields in the Main window. The same may also be done in

one step my double-clicking on a site name in the list. If Set is pressed and the text field does not exactly match any entry in the list, the Name field in the Main Window is simply set the string without effecting the other fields. The text field may also contain a search pattern. Type Enter or activate the Search button to scroll the list to the next item which contains the text, ignoring case, punctuation and spaces.

Calendar:

The calendar on the right of the Main window is based on local time or UTC, depending upon the Time Zone preference. Selecting a date button will set the date. Buttons before the first of the month and after the last of the month work as expected, that is, they also imply a change in month or year as necessary. The month and year buttons pop up selections that allow these to be changed as well. At the bottom are buttons to set the time and date to the computer clock, or move backwards or forwards by one day or week. Except for Now, using the calendar does not change the current time (just the date). New and Full Moons are marked on the day on which they occur in the selected time zone.

2.1 File menu

The "File" pulldown contains a few miscellaneous controls.

System log...

> displays a scrolled list of informational messages. XEphem may beep whenever a new message is added, depending on the "Log Bell" preference; see below. Messages appearing immediately in attention boxes are also logged here for reference.

Network setup...

> displays a window offering choices for how *XEphem* accesses the Internet (§2.1.1).

External file...

> drives *XEphem* from a file containing times and latitude/longitude locations. See its own help for details (§2.1.2).

Progress Meter...

> displays a simple bar graph of XEphem progress. The accuracy and usefulness of the display are highly problematic at this time.

Forward 1 Step

> causes Time to be changed by one Step value. This action can also be performed when the cursor is over any XEphem window by typing Control-f. Invoking this command also stops looping if it is running.

Backward 1 Step

> causes Time to be changed by the negative of one Step value. This action can also be performed when the cursor is over any XEphem window by typing Control-b. Invoking this command also stops looping if it is running.

Update

> performs the same action as the Update button across the bottom of the Main window. This can also be performed by typing Control-u in any XEphem window.

Quit...

> exits XEphem. If any resources have been modified and Preferences -> Confirmations is On, a reminder will first appear and allow you to bring up the Save window if desired. This can also be performed by typing Control-d in any XEphem window.

2.1.1 Network setup

```
Network setup:
◇Direct connect
◇via SOCKS  [1080]  [x.y.com                    ]
◇via Proxy  [8000]  [a.b.com                    ]
☐ Auth Name [          ]  Password [          ]
        [  Ok  ]      [  Close  ]      [  Help  ]
```

This window allows you to define a proxy or SOCKS server to use for the various *XEphem* features that utilize the Internet. One of the following three choices must be enabled for Internet access to be available.

Direct connect:

> This choice just means to use the direct DNS/IP TCP/IP sockets as necessary. Use this one unless you are behind a firewall.

via Proxy:

> This choice attempts to access the Internet via a Proxy. Type the port address and the host name of the proxy in the field provided.

via SOCKS:

> This choice attempts to access the Internet via a version 4 SOCKS server. Type the port address and the host name of the server in the field provided. These values can be initialized using the environment variables SOCKS_PORT and SOCKS_NS.

2.1.2 External Time/Loc

```
File name:
[/home/ecdowney/.xephem/external.txt]

    [  OK  ]   [ Cancel ]   [  Help  ]
```

XEphem can read a file (or fifo) containing sets of time, latitude and longitude values and automatically install these values sequentially unattended. Enter the name of the file in the window and press **OK**. To pause between updates, set the desired delay in the Pause field of the Main window. All features of XEphem, such as plotting and listing, are available while this feature is running (§12).

The format of each line of the file is as follows:

```
        JD Lat Long
```

where

JD	= Julian Date
Lat	= Latitude, radians, +north
Long	= Longitude, radians, +west

The fields are separated by one or more blanks or tabs. All lines not having exactly three floating point values are ignored and may be used for comments, etc.

2.2 View menu

The "View" pulldown brings up any of the several XEphem specialized displays. Each has its own Help so please refer to them for additional information on a particular function.

2.3 Tools menu

The "Tools" pulldown brings up windows allowing full control of the following functions:

plotting data,
listing data,
equation solving,
finding close pairs,
seeing the night at a glance,
retrieving AAVSO light curves
monitoring your local SETI@home client
typing in and converting between coordinate systems.

Each tool has its own Help so please refer to them for complete information on a particular tool.

2.4 Data menu

The "Data" pulldown brings up windows which pertain to managing the objects in memory.

Load/Delete...

adds and deletes catalogs of objects to and from memory. The window also displays overall statistics of the number of each type of object in memory.

Download Internet files...

provides a convenient means to update XEphem databases from the Net. The window comes preconfigured to get timely asteroid, comet and Earth satellite catalogs.

Search memory, ObjX,Y,Z...

selects any given object in memory and views or modifies all of its defining parameters. Also can be used to center the Sky View over any object and to define the user-defined objects, ObjX, Y and Z.

Configure Field stars...

> sets up how and whether to read several very large databases of faint stars which XEphem refers to as "field stars," including the Hubble GSC, USNO, Hipparcos, Tycho and PPM catalogs.

2.5 Preferences menu

The "Preferences" pulldown lists the available preferences that may be changed at run time. Whenever any are changed, all effected fields are immediately recalculated and redisplayed throughout XEphem. The preference include:

Equatorial: Topocentric, Geocentric

> controls whether the RA and Dec values displayed throughout XEphem are for the current local surface location (topocentric) or from the center of the Earth. (Alt/Az values are, of course, always topocentric.)

Precision: Hi, Low

> controls how much precision is shown for most angles. This is a change in display format only and does NOT imply a change in accuracy.

Log Bell: On, Off

> whether to ring the bell each time a new message is added to the System Log window. The System Log window is accessible via the File menu in the Main menu bar.

Prompt Prefill: Yes, No

> whether prompt strings from the Main window and Search windows are filled with the current value or blanked out. This is also handy to allow copy/paste of these values.

Units: English, Metric

> whether local topocentric circumstances are given in English or Metric units of measure.

Time zone: UTC, Local

> whether the time stamp below each major view, the rise/transit/set times in the Data Table window and the dawn/dusk times and the calendar in the Main window refer to UTC or local time.

Show help tips: Yes, No

> whether additional help is available immediately for all selectable buttons and controls using small brief windows near the control.

Confirmations: Yes, No

> whether operations which basically can not be undone or which might have irreversible consequences will be preceded with a confirmation window. Examples include exiting XEphem or overwriting an existing file.

Start week on: Saturday, Sunday, Monday

> sets the day on which weeks begin in the Main calendar.

Date formats: M/D/Y, Y/M/D, D/M/Y

> whether dates are shown and entered in month/day/year, year/month/day or day/month/year format.

Fonts...

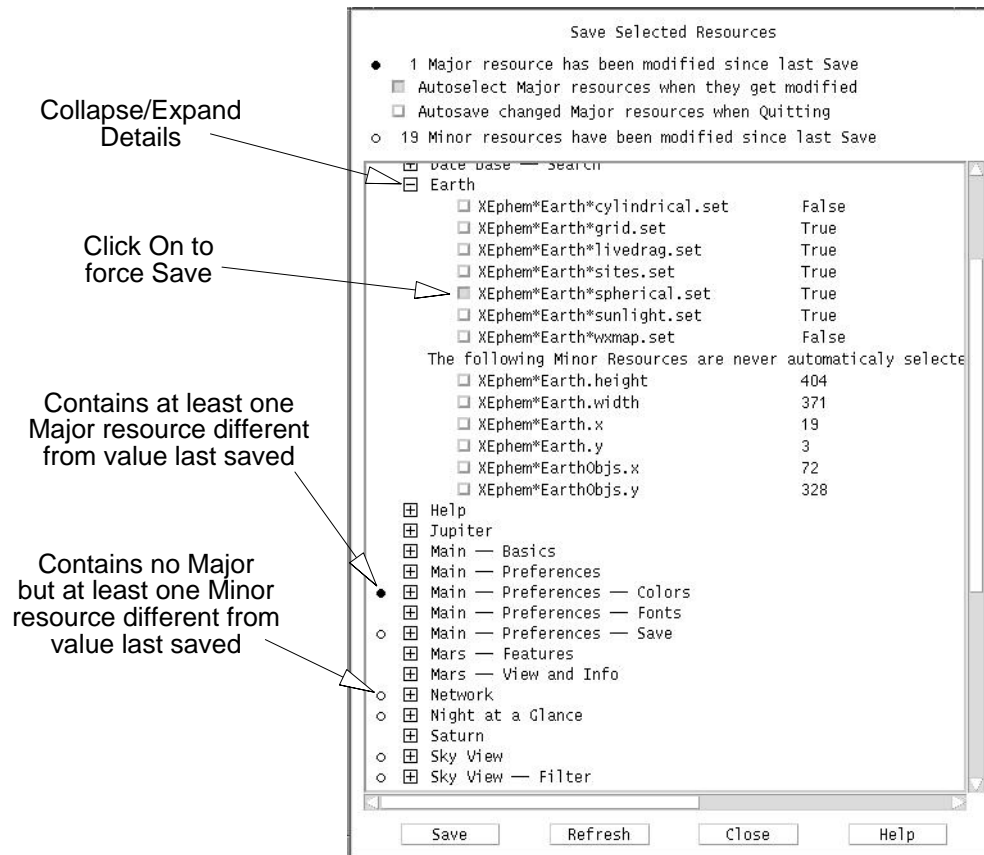> displays a window to experiment with fonts while you watch. See its own help for details, §2.5.2 .

Colors...

> displays a window to experiment with colors while you watch. See its own help for details, §2.5.3 .

Save...

> displays a window which shows how the current functional settings differ from their defaults and allows them to be saved. See its own help for details, §2.5.1 .

2.5.1 Save

```
                          Save Selected Resources
●   1 Major resource has been modified since last Save
        ▣ Autoselect Major resources when they get modified
        ☐ Autosave changed Major resources when Quitting
○  19 Minor resources have been modified since last Save
        ⊞ Data Base — Search
        ⊟ Earth
              ☐ XEphem*Earth*cylindrical.set      False
              ☐ XEphem*Earth*grid.set             True
              ☐ XEphem*Earth*livedrag.set         True
              ☐ XEphem*Earth*sites.set            True
              ▣ XEphem*Earth*spherical.set        True
              ☐ XEphem*Earth*sunlight.set         True
              ☐ XEphem*Earth*wxmap.set            False
          The following Minor Resources are never automaticaly selecte
              ☐ XEphem*Earth.height               404
              ☐ XEphem*Earth.width                371
              ☐ XEphem*Earth.x                    19
              ☐ XEphem*Earth.y                    3
              ☐ XEphem*EarthObjs.x                72
              ☐ XEphem*EarthObjs.y                328
        ⊞ Help
        ⊞ Jupiter
        ⊞ Main — Basics
        ⊞ Main — Preferences
●       ⊞ Main — Preferences — Colors
        ⊞ Main — Preferences — Fonts
○       ⊞ Main — Preferences — Save
        ⊞ Mars — Features
        ⊞ Mars — View and Info
○       ⊞ Network
○       ⊞ Night at a Glance
        ⊞ Saturn
○       ⊞ Sky View
○       ⊞ Sky View — Filter

      [ Save ]   [ Refresh ]   [ Close ]   [ Help ]
```

Collapse/Expand Details

Click On to force Save

Contains at least one Major resource different from value last saved

Contains no Major but at least one Minor resource different from value last saved

This window displays all of the options, settings and controls throughout XEphem which may be saved and reinstated next time the program is started. These are collectively referred to as "Resources" and in fact are saved using the standard X Windows resource database mechanism. XEphem uses many resources, so they are separated into categories in this window for easier management. Each category may be expanded or collapsed using the **+** and **-** control toggles to show each individual resource, if desired.

Resources have been divided into two classes. Most resources are deemed suitably interesting that they can be automatically Saved whenever they change. These are called Major resources. Other resources are considered Minor in nature, meaning the user is likely to change them frequently while operating the program and saving them at any one particular setting is not especially compelling. These are basically window size and position, scale settings which only effect viewing angle and all of the Sky View Filter and Option settings. This distinction is of course rather arbitrary however so please take care when changing and saving resources so just the ones you want are saved.

In the expanded view, each resource and its value are shown exactly as it would appear in the disk file if Saved. Those resources which differ from the last time they were Saved, or since XEphem was started if no Save has yet occurred, are marked with a bullet. A toggle next to each resource allows individual selection over whether the resource will be written to disk on the next Save.

After each Refresh, Major resources which are found to be out of date are marked with a bold bullet and automatically selected to be Saved if the Autoselect option on top is active. Minor

resources are marked with a hollow bullet mark and are never selected for Saving by default. If at least one Major resource is out of date in a category, a bold bullet is placed next to the category heading; otherwise if at least one Minor resource is out of date a hollow bullet is used.

Whether or not any resource is in fact Saved may always be independently set as desired using its toggle. The discussion above refers only to whether the toggle for each resource is set automatically after each Refresh.

A key is provided at the top to remind you to what the two styles of bullets refer, along with a count of the total resources that are out of date in each class.

Note that the information in this window does NOT automatically track changes in resources as XEphem is used. You must use Refresh (see below) to update the status here when desired. In particular, the values which are Saved are what they were the last time Refresh was performed, not what they actually are at the moment Save is activated.

If the Autosave option is both on (located in the upper left) all Major resources that are out of date and selected when XEphem is Quit will automatically be Saved without first being asked to confirm using this window.

The controls along the bottom behave as follows:

Save

Each resource with its toggle button depressed is written to the per-user resource file named at the top. If the file already exists, it will first be copied to XEphem.bak in the same directory. If a resource already exists in the file it will be edited in-place, otherwise a new entry is added at the bottom. Other lines in the file are left unchanged.

After using Save, all resources will be considered up to date, even if they were not selected to be written to the resource file.

N.B. The values saved are as they appear in this window, which may be different from their current value if they have changed since the last Refresh.

Refresh

Updates the changed and save status of each resource in this window. Each Major resource found to be out of date is selected to be saved by default. This refresh action also happens automatically after a Save is performed and just before the automatic Saving if AutoSave is on when quitting.
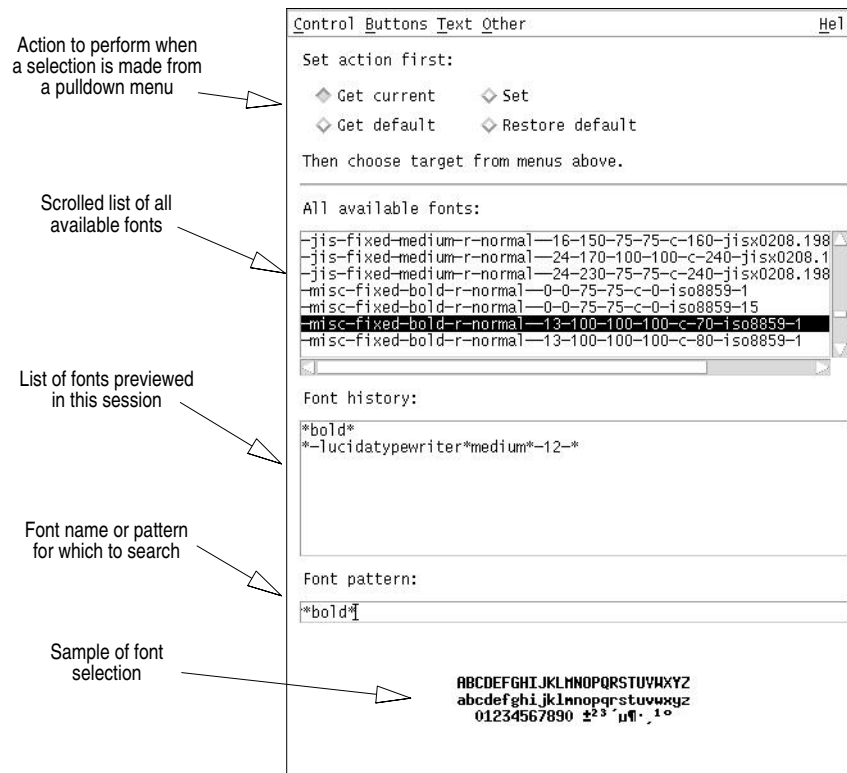
Close

Closes the Save window.

Help

Shows this information.

2.5.2 Save Fonts

Action to perform when a selection is made from a pulldown menu

Scrolled list of all available fonts

List of fonts previewed in this session

Font name or pattern for which to search

Sample of font selection

```
Control  Buttons  Text  Other                          Help

Set action first:

  ◆ Get current      ◇ Set
  ◇ Get default      ◇ Restore default

Then choose target from menus above.

All available fonts:

-jis-fixed-medium-r-normal--16-150-75-75-c-160-jisx0208.198
-jis-fixed-medium-r-normal--24-170-100-100-c-240-jisx0208.1
-jis-fixed-medium-r-normal--24-230-75-75-c-240-jisx0208.198
-misc-fixed-bold-r-normal--0-0-75-75-c-0-iso8859-1
-misc-fixed-bold-r-normal--0-0-75-75-c-0-iso8859-15
-misc-fixed-bold-r-normal--13-100-100-100-c-70-iso8859-1
-misc-fixed-bold-r-normal--13-100-100-100-c-80-iso8859-1

Font history:

*bold*
*-lucidatypewriter*medium*-12-*



Font pattern:

*bold*


          ABCDEFGHIJKLMNOPQRSTUVWXYZ
          abcdefghijklmnopqrstuvwxyz
           01234567890  ±²³´µ¶·¸¹º
```

This window lets you inspect and change many of the fonts used by XEphem.

The top scrolled list shows all fonts currently installed on your system. Selecting one will copy the name to the Font pattern field and show a sample. You can select with the mouse, or by browsing with the Up and Down keyboard arrow keys.

Below that is a list of the fonts recently used in this window for convenient reuse if required. Browsing operates the same way.

The Font pattern is a field in which a Font name may be entered, including the splat character (*) to serve as a wild card if desired. Press Enter or the Search button in the Control menu to find and display a sample of the next matching font, if any. The font named here also applies to the menus of context controls, described next.

The center menus in the menu bar across the top provide ways of referring to several font contexts. The four toggle buttons just below the menu bar determines what happens when one of these context menu buttons is clicked, as follows:

Get current:

> When this toggle is active, clicking a context menu button will cause the name of the current font for that context to be displayed in the pattern field and history list.

Get default:

> When this toggle is active, clicking a context menu button will cause the name of the last saved default font for that context to be displayed in the pattern field and history list.

Set:

> When this toggle is active, clicking a context menu button will cause the font named in the pattern field of this window to be applied to that context throughout XEphem.

Restore default:

When this toggle is active, clicking a context menu button will cause its last saved
font value to be reinstated through XEphem.

Fonts that have been changed from their default values are tagged in the Preferences->Save
window (after you do a Refresh). This allows you to Save the new font choice permanently. If you
do not Save it, the change only effects XEphem until you exit.

There are a few situations scattered around within XEphem for which changing fonts at runtime
from this window does not work perfectly. For example, changing to a smaller font does not shrink
some windows as much as you might expect. Such anomalies are known challenges and do not
indicate serious problems. After Saving the fonts and restarting XEphem, all will work again as
expected.

2.5.3 Save Colors
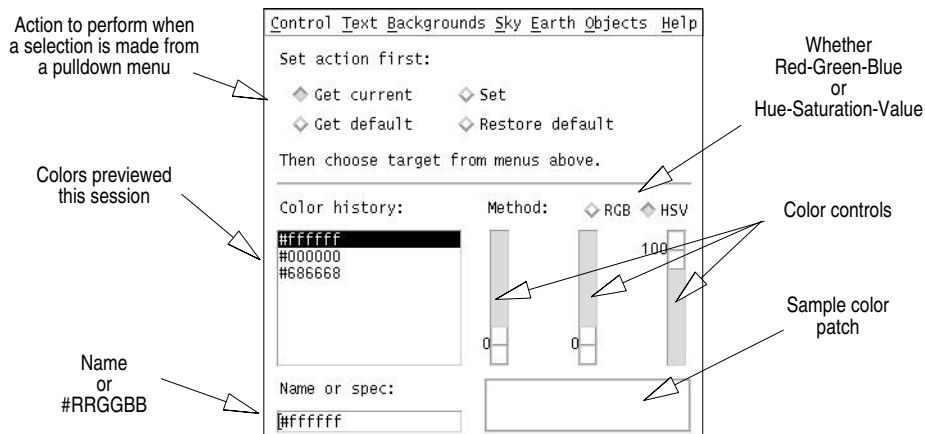
This window lets you inspect and change many of the colors used by XEphem.

The top four toggle buttons determines what happens when an entry in a color context menu is
clicked. The effects are as follows:

Get current:

When this toggle is active, clicking a color context menu button will cause the
current color for that context to be displayed in the color patch in the lower right
corner of this window.

Get default:

When this toggle is active, clicking a color context menu button will cause the last
saved default color for that context to be displayed in the color patch in the lower
right corner of this window.

Set:

When this toggle is active, clicking a color context menu button will cause the color currently being displayed in the color patch of this window to be applied to that context throughout in XEphem.

Restore default:

When this toggle is active, clicking a color context menu button will cause its last saved color to be reinstated.

Above the color patch are three sliding scales that allow you to define a color using either Red/Green/Blue or Hue/Saturation/Value, depending on the toggle. Hue is the pure spectral color, where 0 is red, 33 is green, 66 is blue and 100 is back to red. Saturation is the amount of color purity, where lower values mix in more white. Value is like brightness, where 0 is totally black.

The text field at lower left allows you to type a color using one of the standard descriptive names, such as "steel blue", or in hex RGB notation, for example #ff0000 for pure red, #00ff00 for pure green #0000ff for pure blue. After typing the desired value, press Enter to set the scales and see the color in the patch. This field is also set automatically when the scales are used to set a color, during Grabbing (see next), and when a color context is retrieved.
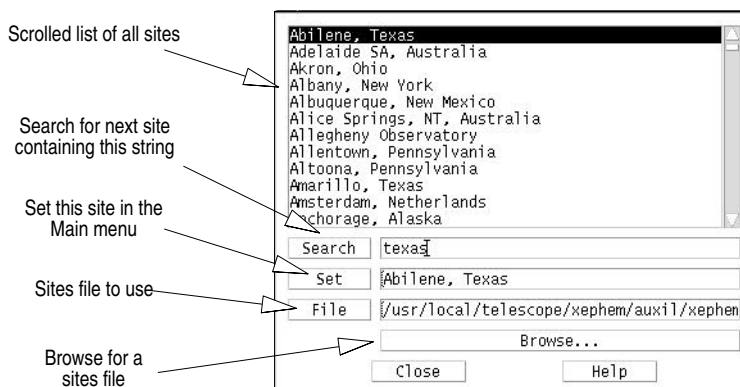
In the Control menu is a toggle button for Night vision. This changes the XEphem background to black, and uses the Night vision color for all text. Clicking this back off will restore the previous colors. Note that when Night vision is on, you may not change the colors it effects. This is to eliminate confusion with regards to wheter or not they are new in the Save window.

In the Control menu is a button labeled Grab. It may be used to capture any color on the screen. Press this button and the cursor will change to a crosshair. Move the cursor around on the screen and the color of the pixel under the crosshair will be displayed; press Button1 to capture the color and resume normal cursor operation.

The history list in the lower left stores each color name that is used from the name field, making it easier to reuse a color. Selecting a name will copy it to the name field and show it in the color patch. You can select history entries with the mouse, or by browsing with the Up and Down keyboard arrow keys.

When a color context is changed, it also changes the corresponding resource. In the Preferences->Save window you will notice that the resource becomes marked as Modified (after you do a Refresh). This allows you Save the new color choice permanently. If you do not Save it, the change only effects XEphem until you exit.

2.6 Sites dialog

Scrolled list of all sites

Search for next site containing this string

Set this site in the Main menu

Sites file to use

Browse for a sites file

| Abilene, Texas |
| Adelaide SA, Australia |
| Akron, Ohio |
| Albany, New York |
| Albuquerque, New Mexico |
| Alice Springs, NT, Australia |
| Allegheny Observatory |
| Allentown, Pennsylvania |
| Altoona, Pennsylvania |
| Amarillo, Texas |
| Amsterdam, Netherlands |
| Anchorage, Alaska |

Search   texas

Set   Abilene, Texas

File   /usr/local/telescope/xephem/auxil/xephem

Browse...

Close   Help

This window allows you to load, search and select one of a collection of predefined sites.

The scrolled list at the top lists the complete set of currently defined sites. Clicking on one will copy it to the Set text field. Double clicking on one will also install it to the Main window, as will clicking on Set or typing Enter over the select text field.

To search for a particular site, either scroll through the list or enter any part of the site designation in the Search text field. Clicking on Search or typing Enter in the search text field will scroll the list to the next site that contains the search text, ignoring case and blanks.

A new file of site definitions may be installed at any time. Type in the name of the file test field then type Enter or click on File to read in the file. Or click on Browse and use the File Selection Dialog to locate the desired site file. Pressing Ok in the FSB or double clicking on a file name will load the new file and close the FSB window.

File format:

XEphem stores sites in the file xephem.sit. Each line in the file consists of 5 fields, each separated by a semicolon (;), as follows:

Name ; Latitude ; Longitude ; Elevation ; Timezone

where:

Name is the City, State, Country or other designation, up to 40 characters.

Latitude is DD MM SS, followed by an N or S to indicate north or south of the equator. Each portion is separated by a blank.

Longitude is in DDD MM SS, followed by an E or W to indicate east or west of the prime meridian in Greenwich, England. Each portion is separated by a blank.

Elevation is in meters. If you do not know your elevation, put "-1.0".

Timezone indicates the offset from GMT and savings time information. The format matches that of the POSIX standard fully described in the manual page for the tzset(3) function. The format is basically summarized as:

std offset dst [offset],start[/time],end[/time]

Here are a few examples:

```
Munich, Germany     ; 48 14 0 N ;  11 57  0 E ;   523 ; MET-1METDST,M3.5.0,M10.5.0
New York, New York ; 40 45 6 N ;  73 59 39 W ; 16.8 ; EST5EDT
Sydney, Australia   ; 33 52 0 S ; 151 12  0 E ;  7.6 ; EST-10EST,M10.5.0,M3.5.0
```

Lines in the file which do not conform to this structure are ignored.

2.7 Examples

Follows are some example goals and worked solutions to practice using some of the XEphem features.

2.7.1 Sky tonight

This example will take us through a session which explores the sky tonight at midnight. Of course, you can do this for any night by setting the desired date first on the Main window.

Set time to midnight tonight:

Main->Local Time->Midnight Tonight

Main->Update

Display the available database files:

Main->Data->Load and Delete...

Load up several database files, as desired, by double-clicking in the
list at at the bottom:

Data Base->YBS.edb   // Yale Bright Star catalog
Data Base->Messier.edb // Messier catalog
Data Base->NGC.edb   // RNGC objects (all but Messier)
Data Base->SAC.edb   // even more deep-sky objects
Data Base->asteroids.edb // many asteroids

Bring up the sky view:

Main->View->Sky View...

Explore around using mouse pointing and/or by sliding field-of-view and
pointing controls as desired.

Save the objects in the Sky View in a file:

Sky View->Control->List...

Make a printed copy:

Sky View->Control->Print...

Now let's focus in on some close encounters. Let's switch to RA and Dec
coordinates, tighten up the field and increase the limiting magnitude so
we can see fainter things:

Sky View->Control->Options->Coord:RA-Dec
Sky View->FOV-> slide to 2.0
Sky View->Control->Filter...
 Sol Sys Lim Mag -> slide to 14
 Stars Lim Mag -> slide to 14
 Deep Sky Sys Lim Mag -> slide to 14
 Ok

You'll probably want to use the Topocentric preference from the Main window:

Main->Preferences->Equatorial->Topocentric

Open the Close objects window, build a list of all moving objects within,
say, 1 degree of each other:

Main->Tools->Find close pairs ...
 Close->Max sep-> enter 1.0
 Close->Mag limit-> enter, say, 13
 Close->Options->Omit fixed pairs // if not already on
 Close->Control->Go   // might take a moment..

Now scroll through your set and find something that looks good. For

example, tonight I happened to find asteroid 702 Alauda passing within 16
arc minutes of the bright open cluster NGC 6416. Double click on the
row and the Sky View will swing around and show it to you. You might want
to tweak up the field-of-view a bit.

If you've chosen an asteroid, let's plot its motion over several hours. Put
the mouse near the asteroid, click button 3, pull down to "Create Trail..."
and let go. You'll get a trail setup window:

        Trail->1 Hour
        Trail->First+Mid+Last
        Trail->Number of intervals: enter 24
        Trail->Ok

If you get a wild array of lines, be sure Sky View->Control->
Options->RA-Dec is set. You may click on any of the tick marks with
mouse button 3 to get the circumstances of the asteroid at the
various times along the trail. You can change the trail parameters
by using "Change Trail..." and proceeding as before.

With luck, you'll have a pretty appulse to watch.

2.7.2 Solar eclipse path

This example displays the location of totality on the Earth for the solar
eclipse of July 11, 1991.

    for convenience, use UTC for all time displays:
        Main->Preferences->Time zone->UTC

    set time to 17:25:00
        Main->UTC Time
            enter 17:25:00 then Ok (or just Enter).
            note you may use almost any punctuation character instead of ":"
                and you need not give leading zeros. for example: "17;25;0".

    set date to 11 July 1991:
        Main->UTC Date
            enter 7/11/1991
            note this should be entered according to the current date format
                preference. for example, after
                    Main->Preferences->Date formats->Y/M/D
                you would enter the same date as "1991/7/11".

    commit to new date and time:
        Main->Update   (note NEW CIRCUMSTANCES stops flashing)

    display the Earth:
        Main->View->Earth...

    A black cross should appear a little southwest of Hawaii. That is the
        current center of totality.

    display the subearth point of the Moon, i.e., the point on the Earth's
        surface at which the Moon is directly over head:

Set Moon as current object:

Control->Objects...

Click on Display and Label.

One may now easily read off the local altitude of the Moon by comparing
with the circles of 0, 30, 60 and 90 degree altitudes. More precise
values for altitude, and azimuth, may be obtained for any location
using the right mouse button.

change Main location to Mauna Kea Observatory:
move cursor near southeast edge of Hawaii, hunt around clicking right
button until the popup says Mauna Kea, slide down and let go over
"Point"
Earth->Control->Set Main
the white Plus on the Earth should move over Mauna Kea and the
central longitude should shift to approximately 155 degrees west.
Note the Latitude and Longitude in the Main view are also updated.

Zoom the view to show the sky from Hawaii:
Main->View->Sky View...
Sky View->FOV->1   (move left scale up until it says about 1.0)
Sky View->Locate->Sun
move cursor over the center of the Sun, select right button, pull
down and let go over "Track"
make sure Sky View->Control->Options->Alt-Az is selected
(or Main->Preferences-> Equatorial->Topocentric is set)
to get a topocentric point of view.

set up a movie showing the path of totality for the next two hours:
Main->N Steps-> enter "24", then Enter
Main->Step->0:05:00
Main->Pause->1
Main->Update

2.7.3 Sky trail

This example will use the Sky View to display a trail of the appulse between
asteroid 121 Hermione and NGC 7293 which occurs about July 28, 1995. We also
demonstrate displaying stars from the Hubble GSC catalog in the sky background
This example is taken from Sky and Tel, July 1995, page 72.

for convenience, use UTC for all time displays:
Main->Preferences->Time zone->UTC

set time to 00:00 using shortcut:
Main->UTC Time:->00:00:00

set date to 24 July 1995 using the interactive calendar:
Main->(Year)->1996
Main->(Year)->1995
Main->(Month)->July
Main->24

commit to new date and time:
   Main->Update   // note NEW CIRCUMSTANCES stops flashing

read in asteroid and NGC databases:
   Main->Data->Load/Delete ...
      in lower right corner, double-click on "asteroids.edb"
        (or could have single-clicked and then pushed Append)
      similarly, double click on "NGC.edb" (scrolling a bit if necessary)
      Control->Close

select 121 Hermione to be Object X:
   Main->Data->Search memory, ObjX,Y,Z...
   in the upper center, click on ObjX
   in the lower right, type "hermi" then Enter in the Search text field
      (this finds 121 Hermione in memory and stages it to become ObjX)
      (you may also browse by scrolling through the list at right and
       selecting the candidate object's button).
   load this into Object X and dismiss the window:
      Ok

display asteroid trail on sky view:
   Main->View->Sky View...
      Locate->121 Hermione
      set Field of View to about 1.5 degrees using scale on left
      Control->Filter..
        set "Sol Sys Lim Mag" to 16 using scale
        Ok
      place cursor over the central dot (Hermione!) and press button 3:
        Create Trail...
          Orientation: Left
          Interval: 1 Day
          Label: Every 2
          Format: Date
          Font: Small
          Number of tick marks: slide to 8
          Ok
      center the trail by placing cursor near dot for 7/28/95 and press
      button 3, then scroll down and release on:
        Center

add nearby Hubble Guide Star Catalog entries:

   If you have not already done so, set up the source for the GSC stars:
      Sky View->Control->Field Stars...

   Enable viewing Field Stars and load an initial set:
      Sky View->Control->Options->Field Stars

   The GSC stars will now be read in and displayed.

if desired, overlay with a coordinate grid:
   Sky View->Control->Options->Grid
   (making the Sky View wider will allow room for more grid labels)
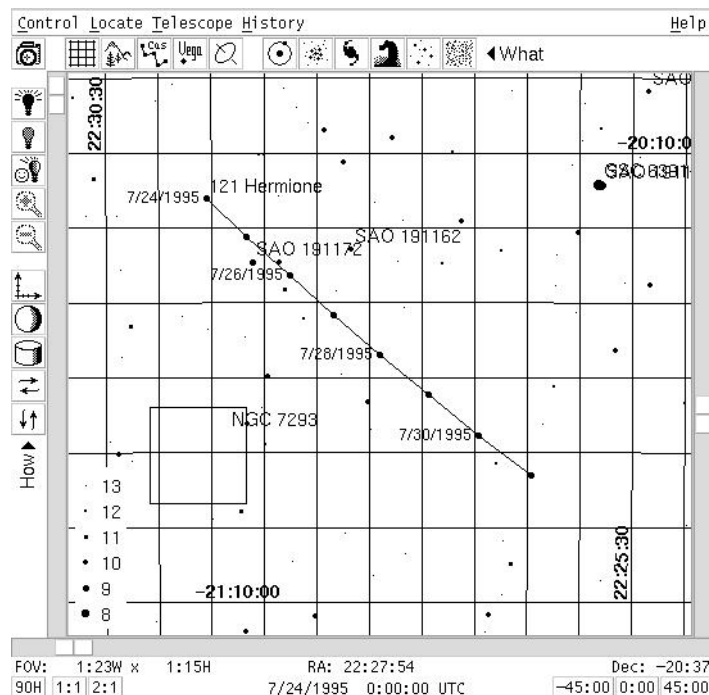
As another example, investigate the appulse between M21 and 241 Germania near
July 15, 1995. Use ObjY for the asteroid so you can leave ObjX as Hermione.
If you have your Sky & Tel handy, this is also described on the same page as
the above reference. From the picture in that article, you can see that the
elements shipped with XEphem for 241 Germania no longer quite match the epoch
of the image, and the Saguaro Astro Club entry for M21 is slightly too far
south and east. This emphasizes an important note: XEphem is only as good as
its databases.

2.7.4 Displaying images

This example will go through displaying an image in the Sky View. The image may be either a
FITS file on your local disk, or may be retrieved via the Internet.

Bring up the Sky View display:

Main->View->Sky View...

Bring up the Image control window:

Sky View->Image->Load and Save...

To display a FITS file, use the file selection window at the bottom to browse your local file system.
When the you have found the file, select it in the list and press the Open button. The image will
be displayed in the Sky View.

Note: In order to be displayable by XEphem, the FITS file must be in 16 bit image format (BITPIX
16).

Or, to retrieve a Digitized Sky Survey image, use the Sky View scales to center the view on the desired sky location, set the field of view scale as desired, select either of the buttons at the top labeled STScI or the ESO the click Get. For these to work you must have a live Internet connection.

STScI is located in Maryland, USA. ESO is in Germany. They both provide identical service so use whichever gives you better network performance. The maximum size of an image retrieved in this manner is currently restricted to 30 arcminutes.

Once an image is displayed by either method, all Sky View features are available. So, you may add a grid overlay, load and display field stars, track the coordinates with the cursor, etc etc, as with any Sky View. Investigate the various Controls from the menubar of the Sky View to see what all is available. For example, if your image has WCS or DSS coordinates, to display field stars over the image:

Set up a source for the field stars (if not already set up):

    Sky View->Control->Field Stars

     (follow the directions in the Help)

Turn on the following options (if not already on):

    Sky View->Options...

     Auto mag
     Field Stars

Next explore the image processing capabilities:

    Sky View->Images->Processing tools...

The image will remain in the Sky View until the direction is changed. If you loaded a DSS image, you may want to save it to your local disk for easier access next time.

2.7.5 Sunrise plot

In this example, we will plot the times of local dawn, sunrise, sunset, and dusk over the course of 2001.

  Set the date to Jan 1 2001:
    Main->Local Date-> 1/1/2001
      you might have to enter this differently depending on your current
       Date Formats preference.

      you could also set the date by using the interactive calendar at
      the right: select the current month, slide and release over January.
      then push the "1" date on the calendar.

  Show times in local timezone:
    Main->Preferences->Time zone->Local

  Set the time to local midnight:
    Main->Local Time-> select 00:00:00 shortcut

commit to the new date and time:
   Main->Update   (note NEW CIRCUMSTANCES stops flashing)

bring up the data table:
   Main->View->Data Table...

   (if the RisTm and SetTm columns and the Sun row are not visible, use
   the Setup option to enable at these columns and rows.)

bring up the plot control window:
   Main->Tools->Plot...

define a plot with four independent traces with local date on their X axis:
   Plot->Select fields
      (note how all labels which can be used for plotting now look and
      operate like buttons. as you press them, they form the definition
      of what will be saved for plotting; watch the X and Y columns of
      the Plot window be filled in as you define the variables to plot).

   Main->Local Date
   Main->Dawn

   Main->Local Date
   Data->Sun.RisTm

   Main->Local Date
   Data->Sun.SetTm

   Main->Local Date
   Main->Dusk

   Plot->Select fields   (turns buttons back to labels)

   When you are finished, the lower portion of the Plot window should look
   like this:

Tag	X	Y
A	LD	Dawn
B	LD	Sun.RisTm
C	LD	Sun.SetTm
D	LD	Dusk

   If you make a mistake, you must start over (Undo is on my list :-)

   If you wish, you may edit the Tags to more accurately denote their
   meaning, such as D, R, S and d. Case is significant, but you only get
   one character.

Set up Main to generate data every other day for 182 steps, i.e., span about
one year:

   Main->N Steps->182
   Main->Step-> enter 2d, then select Ok (or type Enter)

Give the plot a title in the text field provided:

Type: Local Sun Dawn/Rise/Set/Dusk time for 2001

Define a file to contain the plot values:

Plot-> enter a file name in the text field, such as sun2001.plt

Start capturing XEphem plot data to the plot file:

Plot->Create plot file

Let XEphem run:

Main->Update

Note that as it runs, XEphem does not update many values and they are made to look unusual. This is for speed. It only does this if Main->Pause is set to 0. If Pause is anything greater than 0, all values are drawn. In any case, internal values are always updated; it's just the display that is eliminated for a little more efficiency.

Also, things will go fastest if the Data Table is only showing what is necessary, such as turning off all but the Sun row in this case..

When it stops, display the year of plot data:

Plot->Show plot file

Note how the "Plot->Create plot file" option is automatically disabled. Also note the spring and fall discontinuities in the plot if you observe Daylight Savings time in your time zone.

Change the X axis label to be a little easier to relate to:

Plot->View->Show X-Axis as Dates

Here is an example for Chicago:
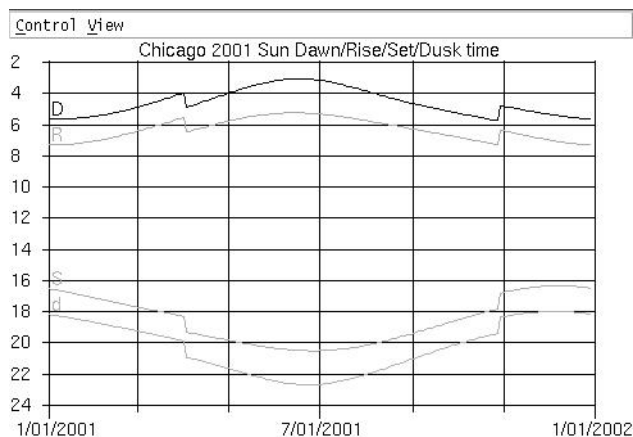
2.7.6 Ring crossing

This example will demonstrate the programmable equation solving feature by

solving for the time when the Earth crosses the ring plane of Saturn.

Generally when using the solving feature of XEphem, a plot of the function should be made first to investigate the general behavior of the function over time and to form an initial estimate of the solution. Hence, our first step is to make a plot of ring plane angle throughout 1995.

Use UTC for all time displays:

   Main->Preferences->Time zone->UTC

Set the date to Jan 1 1995:

   Main->Local Date-> 1/1/1995
      You might have to enter this differently depending on your current
       Date Formats preference.

      You could also set the date by using the interactive calendar at
      the right: select the current month, slide and release over January.
      then push the "1" date on the calendar. Do the same sort of thing
      to set the year.

Set the time to UTC midnight:

   Main->UTC Time->00:00:00

Bring up the Saturn diagram and supporting information views:

   Main->View->Saturn...
      Saturn->View->More info..

Bring up the plot control window:

   Main->Tools->Plot

Select one function to plot, UTC Date vs. Earth ring tilt:

   Plot->Select fields   // turn on
      Main->UTC Date
      Saturn info->From Earth
   Plot->Select fields   // turn off

Specify plot file name and give it a title:

   Plot->File name: rings.plt
   Plot->Title: Saturn Earth Ring Tilt for 1995

Enable plot file capture:

   Plot->Create plot file

Accumulate 180 steps, each 2 days:

   Main->N Steps   enter "180" then Enter
   Main->Step   enter "2d" then Enter
   Main->Update   // runs through 180 steps, rather subdued. it

　　　　　　　　　　　　// runs faster if you close the Saturn view.

Display plot file,

    Plot->Show plot file
    Plot file->View->Show X-Axis as Dates

```
Control View
           Saturn Earth Ring Tile for 1995
7  A
6
5
4
3
2
1
0
-1
 1/01/1995        7/01/1995        1/01/1996
```
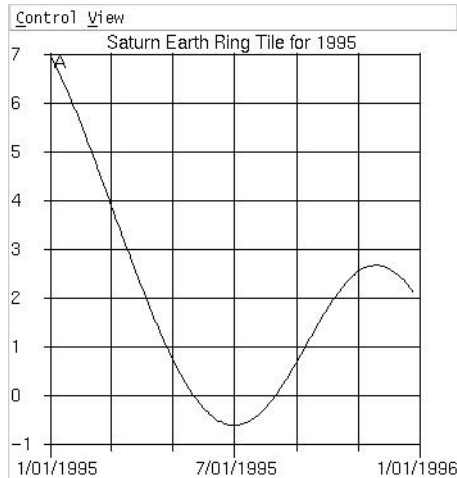
There are evidently two crossings (i.e., where the tilt angle is 0), one in late May and one in
early August. Lets solve for the one in August:

    Main->December->August
    Main->Update　　　　　　　　　　// to engage NEW CIRCUMSTANCES

Open the Solve control window, set up to solve for when the Earth ring
tilt goes to zero:

    Main->Tools->Solve...
       Solve->Enable field buttons // turn on
         Saturn info->From Earth
       Solve->Enable field buttons // turn off
       Solve->Compile
       Solve->Find 0
       Solve->Solving is Active

```
         Solver is Active
Function:                    Clear
"Saturn.ETilt"

No compile errors
   Enable field buttons
         Compile

Goal:
 Find Extreme
 Find 0
 Binary

Desired accuracy:    0:02:00
Current value:    2.41637e-06
      Close      Help
```

And go:

    Main->N Steps->1000000
    Main->Update

The looping stops at Aug 10, 1995, at about 19:24 UT. The August 1995 Sky and Tel, page 72, says it occurs at about 21h +- 2.

2.7.7 Lunar occultation

This example was taken from the lunar occultation of Spica (Alpha Vir) which occurred January 23, 1995, UTC, as reported in Sky and Telescope, January 1995.

If the YBS.edb database is not already loaded, load it now so that Spica is loaded in the XEphem database:

    Main->Data->Load/Delete...
        YBS.edb
        Append
        Control->Close

Set UTC Zone preferences:

    Main->Preferences->Time zone->UTC

Set the Topocentric Equatorial preference:

    Main->Preferences->Equatorial->Topocentric

Set Equinox to EOD (occultations must always be computed using EOD):

    Main-Equinox

    select EOD

Set up the date and time to Jan 23, 1995, 11:45:00 UT, using the calendar and the "UTC Time:" selections in the Main window.

Set the Step size to one minute (0:1:0) using the Step selection in the Main window.

Set the location to Chicago, using the Site selections in the Main window:

    Main-><Site>
        type "chicago" into the Search field,
        type Enter,
        type Set
        select Close

        or

        scroll down to "Chicago, Illinois" and double-click on it.

Main->Update

Display the Moon:

Main->View->Moon..

Make sure the true Sky background option is enabled:

Moon->View->Sky background

Spica is just behind the dark western limb, ready to emerge. To see it, press Main->Update to advance the time by 1 minute. Spica appears at 11:47 and near the craters depicted in the schematic on page 83.

An analytical method is to use the Main->Tools->Solve method to find the time when the following equation evaluates to zero:

"Spica.Moon"-"Moon.Size"/7200

Set the Desired Accuracy to 0:0:1 and one finds the occultation occurs at 11:46:10 UTC.

2.7.8 International Space Station

This example will show how to display the ground track for the International Space Station in the Earth View, find when it will next be visible in your location, and display its path through the sky overhead in the Sky View.

First be sure XEphem has a working connection to the Internet

click Main->Network Setup
click on the appropriate choice

Get fresh elements from the web:

bring up Main -> Data -> Download Internet files
Type "ISS" in the Search field and turn on the toggle
click "Get" next to the entry for stations.txt
click Assign to "ObjX"

Show the current position of the ISS in the Earth view:

bring up Main -> View -> Earth, then Control -> Objects
click the left menu button at the top, slide down to ISS and release.

Create a ground track for the next few hours:

click the Trail button in the column used for ISS.
slide Number of tick marks to about 50
select Orientation->Up, Font->Small
click Apply

For fun, show in "mission control" format:

click Earth->View->Cylindrical

Set your location:

    click on the button below "Location" in the Main window
    scroll through the list and click on a city near you
    click Set
    click Close
    in Main, click Update at the bottom

To get a quick idea of all times when IIS is visible at your location:

    click on Main -> Tools -> Night at a glance

        the dotted light near the bottom shows all times when IIS is
        visible between noon today and noon tomorrow.

To see the next time ISS will rise in your location:

    click Main -> View -> Data table

    The next rise time is in the RisTm column. If this column is not visible:

        bring up Control -> Setup
        toggle Rise/Set -> RisTm so it is On
        click Apply

    The highest it will get on this pass is in the TrnAlt column. If this
    column is not visible:

        bring up Control -> Setup
        toggle Rise/Set -> TrnAlt so it is On
        click Apply

Note the RisTm (from above) and set the the Date and Time in the Main
window to about 30 seconds or so later. Be sure to use UTC or Local
depending on Main -> Preferences -> Time zone.

Show the path overhead in the Sky View:

    check that Main -> Preferences -> Equatorial is set to Topocentric
    click Main -> View -> Sky View...
    check that Sky View -> Control -> Options -> Orientation set to Alt-Az
    slide the FOV to a full 180 degrees
    click Sky View -> Locate -> ISS to mark the ISS on the sky map
    move the mouse over the ISS, press the right mouse button, slide down
        and release over Create trail...
    select Interval/Custom and type in one minute as 0:01
    also set these options for starters:
        Orientation/Up
        Format/H:M
        Font/Small
        Label/Every 2
        Start/Whole interval
    slide Number of tick marks to about 10
    click Apply

Main Window

10/13/2001 15:19:07 CDT
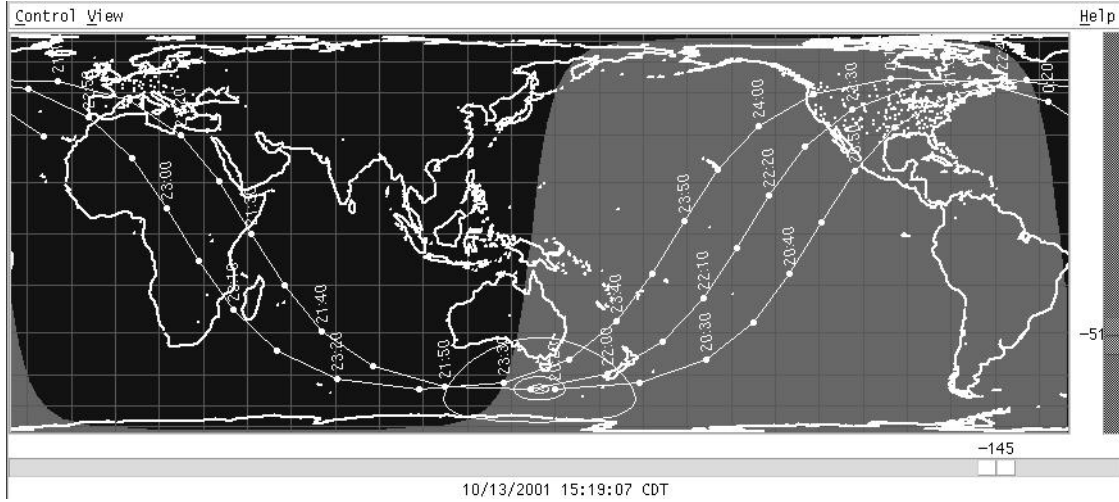
3 Data Table

```
Control                                                              Help
              Cns    Az       Alt      Zenith   VMag  Elong RisTm TrnTm TrnAlt SetTm
Sun           Lib  57:54:29 −54:28:28 144:28:28  −27    0.0 12:55 17:51 29:37 22:47
Moon          Tau 170:52:24  68:54:39  21:05:21  −13 −147.3  1:26  8:11 69:08 15:54
Mercury       Vir  68:28:47 −36:36:12 126:36:12 −1.6  −19.3 11:13 16:38 37:36 22:03
Venus         Sgr 328:47:47 −71:24:19 161:24:19 −4.1   39.3 16:17 20:39 22:33  1:01
Mars          Vir  80:40:08 −12:10:19 102:10:19  1.7  −46.0  8:59 14:56 46:41 20:54
Jupiter       Tau 214:46:47  65:24:04  24:35:56 −2.8 −164.2 23:31  6:57 68:45 14:19
Saturn        Tau 228:26:40  57:33:22  32:26:38  0.5 −173.9 23:05  6:17 65:28 13:25
Uranus        Cap 278:36:54 −34:05:05 124:05:05  5.8   84.8 18:47 23:48 31:40  4:49
Neptune       Cap 286:46:22 −45:31:42 135:31:42  7.9   71.8 18:04 22:55 29:00  3:45
Pluto         Oph  17:41:28 −58:55:34 148:55:34 13.9   22.2 13:59 19:17 36:07  0:36
ISS (ZARYA)   Men 184:14:56 −29:52:37 119:52:37             9:43  9:46  3:12  9:49
Limb 11/14/2000  7:56:07 UTC
```

This is a table of information about each planet, the Sun, Moon, and any three user defined objects, ObjX, Y and Z. Each data item occupies one column in the table and each object occupies one row.

The Control pulldown menu contains the following options:

Setup ...

This button brings up a configure window to specify the table rows and columns as desired.

List ...

This button allows the current data table to be saved in a text file.

When any columns related to rising or setting are active a box at the bottom will indicate whether the times refer to the center or the upper limb of the object. Similarly, when either the RA or Dec columns are active or any of the separation columns are active a box will be present to indicate whether the separation is from a geocentric or topocentric point of view. The box will also indicate the precession epoch. See the help for the "Setup" window for more information about these modes.

Any of the information in this table may be plotted (§12.1), listed (§12.2) or used in a solver algorithm (§12.3). See the help for these control functions for more details.

See the help for the "Setup" window for a description of each column.

3.1 Setup window

```
Rows:            Columns:
     Objects        Miscellaneous    Rise/Set    Separations
     Toggle            Toggle        Toggle        Toggle
      All               All           All           All
     Reset             Reset         Reset         Reset
 □ Sun         □ Cns    ▪ HeLat    |0            ▪ Sun
 ▪ Moon        ▪ RA     ▪ HeLong   ◇ Limb        ▪ Moon
 ▪ Mercury     ▪ HA     ▪ GLat     ◇ Center      ▪ Mercury
 ▪ Venus       ▪ Dec    ▪ GLong    □ RisTm       ▪ Venus
 ▪ Mars        ▪ Az     ▪ EcLat    □ RisAz       ▪ Mars
 □ Jupiter     ▪ Alt    ▪ EcLong   □ TrnTm       □ Jupiter
 □ Saturn      □ Zenith ▪ EaDst    □ TrnAlt      □ Saturn
 □ Uranus      ▪ Air    ▪ EaLght   □ SetTm       □ Uranus
 ▪ Neptune     ▪ Size   ▪ SnDst    □ SetAz       ▪ Neptune
 □ Pluto       ▪ VMag   ▪ SnLght   □ HrsUp       ▪ Pluto
 □ ISS (ZARYA) ▪ Phase  ▪ Elong                  ▪ ISS (ZARYA)
        Ok          Apply          Close         Help
```

This window lets you configure which rows and columns will be in the Data Table. When this window first comes up it will be set to indicate the state of the Data Table. You may then manipulate the toggle buttons as desired. To actually change the Data Table to a new configuration select the **Apply** button. **Ok** does the same thing but also closes this window. **Close** just closes this window without making any permanent changes. In addition to manipulating each item individually, each columns includes handy shortcut controls at the top to make changes to column as a whole.

The first column of this window selects which rows will be present in the Data Table. The planets and the Sun and Moon are always in this column. If user defined objects ObjX, Y or Z are defined then they will also be present and controllable from this column. See the help for the "Set ObjXYZ" window for more information about user defined objects (§13.3).

Entries in the remaining three columns in this window control which columns will be present in the Data Table. They are grouped into three categories for convenience.

Column two controls miscellaneous basic information. The descriptions of each entry are as follows:

Cns	name of the constellation in which the object appears.
RA	Right ascension: if Main Equinox is set to EOD this is the apparent place, otherwise it is the astrometric (mean) place. If Main Preference Equatorial is Topocentric, it is further corrected for parallax.
HA	geocentric or topocentric hour angle of object, computed as LST-RA precessed to EOD. Positive angles are west of the meridian.
GHA	Greenwish Hour Angle, hour angle of object when at 0° longitude.
Dec	Declination: if Main Equinox is set to EOD this is the apparent place, otherwise it is the astrometric (mean) place. If Main Preference Equatorial is Topocentric, it is further corrected for parallax.
Az	topocentric degrees eastward of true north for object.
Alt	topocentric degrees up from a horizontal plane that is Elevation feet above sea level. Corrected for refraction.
Zenith	topocentric Zenith distance, degrees; corrected for refraction.
Air	Number of relative air masses through which light from the object passes to the topocentric observer. Computed by the method of Hardie, clamped to a max at 3 degrees altitude.
Spect	Basic spectral classification, if appropriate.
Size	angular size of object, in arc seconds. If not otherwise given, estimated for objects in heliocentric orbits from the absolute magnitude parameter H and by assuming an albedo of 0.10, for which H is 18 for an object of 1.06 km diameter at 1.0 AU.
VMag	visual magnitude of object.

Phase   percent of visible surface in sun light.

Elong   spherical angular separation between the Sun and given object, calculated from the their geocentric ecliptic coordinates. Note this is not just the difference in ecliptic longitude, as is sometimes used. The sign is positive for an evening object or negative for a morning object. Thus, this field is not generally useful in searching for eclipses because of the discontinuous sign change which occurs at conjunction. For that, use the individual Separations fields.

HeLat   true heliocentric latitude, in degrees. For the Moon this is the geocentric latitude.

HeLong   true heliocentric longitude, in degrees. Earth's is displayed on the Sun's line. For the Moon this is the geocentric longitude.

GLat   galactic latitude, in degrees.

GLong   galactic longitude, in degrees.

EcLat   ecliptic latitude, in degrees.

EcLong   ecliptic longitude, in degrees.

EaDst   true distance from Earth center to object center, in AU, except distance to the Moon is in miles or km depending on the Units preference.

EaLght   time for light to travel from Earth to object. Format is hh:mm for all solar system objects, except the Moon is in decimal seconds.

SnDst   true distance from Sun center to object center, in AU.

SnLght   time for light to travel from Sun to object. Format is hh:mm.

Uranom   Volume and Page number of object's location in the original Uranometria, published by Willmann-Bell, Inc.

Uran2k   Volume and Page number of object's location in the new Uranometria 2000 edition.

MillSA   Volume and Page number of object's location in the Millenium Star Atlas, published by Sky Publishing Corp.

Column three controls information related to rising, transitting, and setting. These are computed based on a refraction model that uses the actual atmospheric and topocentric circumstances displayed on the Main window. A text entry field is available in which you may specify a number of decimal degrees the local horizon is above horizontal to account for local effects.

The "Limb" option means that the rise and set circumstances are based on the location of the upper limb of the object. "Center" means that the circumstances are based on the location of the center of the object.

Follows is a description of the Data Table columns controlled by the third Data Selection column:

RisTm
RisAz   The local or UTC time and azimuth when the upper limb (or center) of the object rises TODAY. See note below for Earth satellites.

TrnTm
TrnAlt   For all but Earth satellites, this is the local or UTC time and altitude when the object crosses the meridian TODAY, i.e., when its azimuth is true south or, if no precession, when the local sidereal time equals the object's right ascension. If the object is an Earth satellite, this is the time and highest altitude the satellite ever reaches above the local horizon (at whatever azimuth).

SetTm
SetAz   The local or UTC time and azimuth when the upper limb (or center) of the object sets TODAY. See note below for Earth satellites.

HrsUp   The number of hours the object is up TODAY, that is, the difference between the set and rise times. See note below for Earth satellites.

Note for time zones:

Rise and set circumstances are all computed in local time. If the Time zone preference (from the Main menubar) is set to UTC then the times are converted to UTC. Thus, when reference is made to TODAY it means the current local date, not UTC date.

Note for Earth satellites:

Due to their generally rapid motions Earth satellites often have many rising and setting events per day. For this reason, the rise and set time for satellites are not restrained to be during the current local day. Rather, for satellites, XEphem displays the very next rising and setting events that occur strictly later than the current time on the Main window, provided they occur within 24 hours. This means that if the rise or set time displayed is earlier than the current local time on the Main window, it actually refers to the next day. This doesn't happen for the other objects because their times are restricted to events that happen just today. Similarly, we can only compute the HrsUp column if the set time is strictly later than the rise time.

The upshot of all this is that the best way to really understand the visibility of a satellite in your area is by graphing its altitude over the desired time interval.

Various "odd ball" rising, transit and setting conditions are accounted for and marked when they occur as in the following table. Note that in the case of Earth satellites, "TODAY" really means within the next 24 hours.

NoRise   up some time but never rises, as such, TODAY.
NoSet   up some time but never sets, as such, TODAY.
NoTran   up some time but doesn't transit, as such, TODAY.
CirPol   object is circumpolar (never goes below horizon) TODAY.
NvrUp   object is never above the horizon TODAY.

The last column in the Data Table setup window controls for which objects angular separation is computed. Each entry in the Data Table will be the angular separations between each pair of objects, in degrees.

The vantage point for the Separation values depends on the Equatorial preference in the Main window. "Geocentric" ignores local conditions and gives the separation as seen from Earth

center. "Topocentric" uses the local conditions known to XEphem. The choice is particularly critical for lunar occultations and Earth satellites, of course, but the effect can be significant for the planets as well. Geocentric separations between objects and the Sun will match the magnitude of the elongation given in the Data Table window.

When ObjX, Y or Z are defined, these will appear in the last column and separations between them and the other objects (in column 1) may be selected for display.

Note:

> Solving over a period that will include the rise or set times of either object is generally better performed from the geocentric viewpoint. The refraction effect of the topocentric viewpoint causes many arc minutes of rapid whiplash displacement as the objects rise and set that overlays the smooth celestial motion of the objects. This rapid position variation can confuse the solver algorithms that expect fairly smooth functions.

4 Moon view

This is an image of the Moon, shaded to indicate phase. It may be flipped and scaled as desired and many Lunar features may be labeled, including most spacecraft landing sites. During a Lunar eclipse, the edges of the umbra and penumbra regions are drawn as solid and dashed lines, respectively.
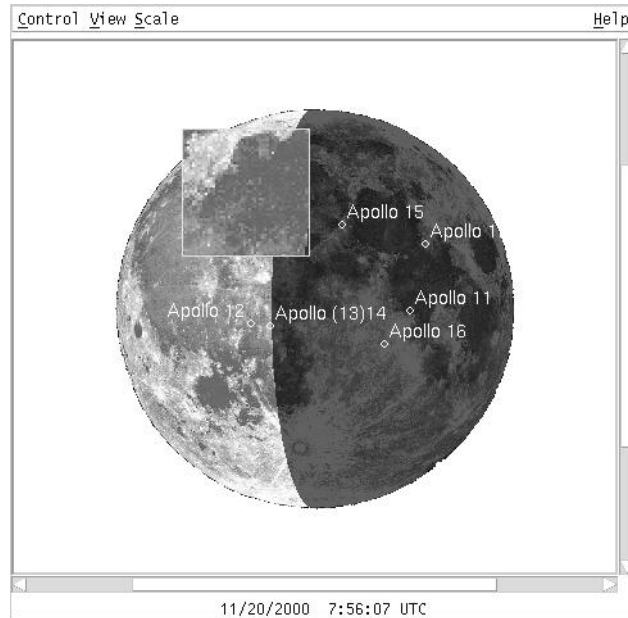
The coordinate system on the Moon is such that latitude increases towards the north and longitude increases towards the east. When facing the Moon with the unaided eye, lunar east is towards the right. The lunar image in XEphem is oriented with the polar axis vertical on the screen. Letters are placed at each edge of the image to show nominal celestial directions.

If at least three colors can be allocated the image is rendered with at most 30 shades of gray; if only two colors can be allocated it is dithered into a black and white image.

The Moon nods and rocks slightly as it moves through the sky. This motion is called libration. A dot is placed on the circumference of the image to indicate the limb position that is currently tilted most towards Earth due to libration. The angular position of the dot is placed accurately but the image rendering is not adjusted for libration effects. Thus, the surface features over which the dot and the terminator appear in the image are only approximate. See the Help for "More info..." under View for more information on libration.

4.1 Mouse functions

Left button:

Activating the left mouse button while over the lunar image will display a small magnified 2x view of the lunar surface under the cursor. The magnified image will track the cursor as it is moved around the image. The latitude, longitude and solar altitude of the location are displayed in the "More info..." window. See Help for View for more information about this window.

Right button:

Activating the right mouse button while over the lunar image will bring up a popup menu. If the location is near an item in the lunar features database, the name of the feature, its type, diameter in miles or km (depending on Preferences->Units), location and solar altitude at its center are displayed in the window. A toggle button will also be present which controls whether the label for the feature will be persistent, that is, shown regardless of whether View->Features is activated. Persistency is automatically reset if the Scale is changed. If the location is not near a feature, then only location and solar altitude are displayed in the window. The algorithm chooses the smallest and closest feature about which to report.

Activating the right mouse button while not over the lunar image but near a sky background object will bring up a popup menu containing the name and magnitude of the object. One of the following two options will also be available:

Assign ->
   To ObjX
   To ObjY
   To ObjZ

This cascade allows you to assign the given object to become ObjX, Y or Z, as desired (§13.3). This will also cause all other views which are currently making use of this object to be updated and the object will be added to and selected by the Data table. Also, since this makes the object one of the User-Defined objects it will now appear directly in the Sky View->Locate pulldown menu.

Show in Data Table:

This option is only offered when the object chosen under the cursor is a planet, the Sun or the Moon. Selecting this option forces the object to be enabled in the Data Table.

The two features may be activated together if desired by first pressing the left button then the right button. This is helpful when trying to locate a particular feature in the magnified view. Try to always release the right button to dismiss the popup before releasing the left button. If you release the left button before the right button, the magnifying glass will remain on the image. If you run into this, you can activate the glass again and mop up the remains of the old glass.

4.2 Control menu

Print...

This selection allows printing the current Moon view or saving it to a file.

Field Stars...

This selection activates the Field Star setup window. For more information about this facility, see the Help for the Field Star window itself.(§13.4)

Set Earthshine...

This brings up a window containing a scale which allows you to set how bright the Earthshine is in the Moon image. The value ranges from 0, black, to 10, full sun light. Full

sun light is useful when you would like to peruse the Lunar surface but would rather not change the XEphem date to a full Moon.

This value depends on the gamma of your display. A fine discussion of display gamma and a test image with which you can determine the gamma value of your own display may be found at the URL:

```
http://www.cs.cmu.edu/afs/cs.cmu.edu/user/rwb/www/gamma.html
```

Movie Demo:

This sets up an automatic display movie of the Moon. This is done by setting the N Steps entry in the Main window to a large value; setting the Step to two hours if Sky background is Off or to one minute if it is On; and starting XEphem looping. The movie can be stopped by selecting this option again or by selecting Stop from the Main window.

Close:

This closes the main Moon display and, if open, the More info window. The image is never updated while it is closed. However, for convenience, if any of the fields in the More Info window are being used for listing, plotting or solving, the continue to be updated even when the window is closed.

4.3 Views menu

Spacecraft:

If set and the Scale is at 6, then all spacecraft landing sites are marked and labeled on the image. If the Scale is less than 6, then only the Apollo sites are marked.

Features:

This sets whether additional (non-spacecraft) Lunar features are labeled on the image. More features are labeled at larger scales. Even at the largest scale, all of the features are not labeled. However, all features are searched at all scales when using the right-mouse click to interrogate a location.

Sky background:

This sets whether to show objects within the current field of view that are in the XEphem database memory or available from the Field Star facility. The size and symbol used for the object matches that of the Sky view when set for a minimum magnitude of 12. While this option is on, XEphem will continue to retrieve field stars as required.

Use real image:

This sets whether to render the Moon using a real image, or just a simple schematic drawing of the sun lit and earth lit portions. The latter option is primarily just for simpler printing. Even while this option is on, the magnifying glass will still show the real image, and the lunar features database is still accessible via the right mouse button.

{Pen}Umbra:

This sets whether to show circles at the edges of the umbra and penumbra during a Lunar eclipse.

Flip T/B:

This sets whether the image is flipped top-to-bottom.

Flip L/R:

This sets whether the image is flipped left-to-right.

Grid:

This sets whether a coordinate grid is drawn over the image. Each line is spaced at an interval of 15 degrees.

Also, the current subearth location is marked with an X; the subsolar point is marked with a small open circle; and the anti-subsolar point is marked with a small filled circle.

4.3.1 More info dialog

This brings up a separate window with additional information.

```
Under Cursor:
Latitude +N:          33:47
Longitude +E:        325:12
Sun altitude:         15:27
Next Sunrise:         13:29
                 12/06/2000
Next Sunset:          19:07
                 11/21/2000

Sunrise Long:        163:04
Subsolar Lat:          1:10
Libr in Lat:          −5:56
Libr in Long:          4:41
Limb angle:          218:17
Tilt:                 7.551

    11/20/2000  7:56:07 UTC
            Close
```

The top portion of the window reports the location of the cursor as it is moved over the image, if the left button is pressed. It also shows the altitude of the Sun and the times when the Sun will next rise and set at that location. The times are in accord with the Time zone Preference in the Main window.

The lower portion of the window shows the lunar longitude of sunrise, the lunar latitude of the subsolar point, and libration information.

The longitude of the subsolar point is at +90 from the sunrise longitude, and the longitude of the anti-subsolar point is at -90. The libration in longitude is positive towards lunar east; latitude is positive towards lunar north. The Limb angle is zero at lunar north and increases towards lunar west. The Tilt is the number of degrees the Moon is tilted towards Earth around an axis defined by the librations in latitude and longitude. The limb location that is titled most towards Earth is indicated on the image by a small dot.

Any of the values in the lower portion may be used for plotting, listing and solving in the usual way as described in the Help entries for these Control options. The values are always current when used in this way, even if the main Moon view is closed. For faster looping, close the main Moon display to prevent it from being redrawn each time.

4.4 Scale menu

This pulldown menu presents a list of factors by which the lunar image may be scaled. The image is presented in a scrolled window for panning if it is larger than the overall window.

5 Earth view

Terminator · Up to 3 simultaneous ground tracks · Sites database · Altitude loci for Horizon, 30°, 60°
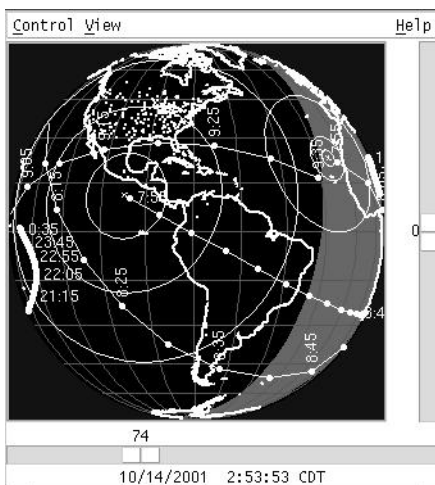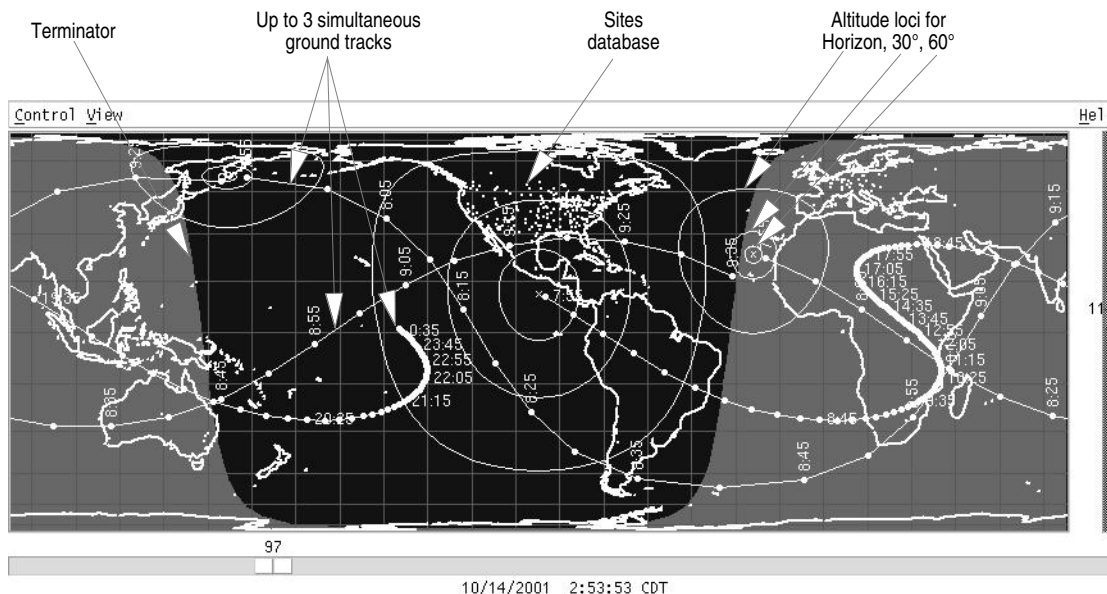
This view displays a schematic of the Earth with continent outlines. The projection may be spherical or "Mission Control" style. The controls available from the menu bar across the top control the view, additional information and the ability to overlay the ground positions of up to three objects. The scales along the bottom and right edges display, and may be used to control, the center location.

Any of basic Planets, Sun and Moon as well as ObjX, Y or Z from the XEphem database may be displayed on the map. The surface location of an object is marked with a bulls eye. The concentric circles indicate the locus of points at which the object appears to be 0, 30, and 60 degrees above the local horizon. When the Earth view is first displayed, the ObjX,Y,Z objects will automatically be preselected and the view centered on ObjX, if they are defined. After that, you are free to change things as desired. Note that these can be preset directly at startup by using .edb database files containing exactly one object each; see Data -> Load -> Help -> on Control for more information(§13.1).

The location defined in the Main window is marked on the map with a plus (+).

If a solar eclipse is occurring on the Earth a small X will mark the location of central totality. Try July 11, 1991 around 18:00 UT or May 10, 1994 around 16:00 UT.

All computations for Earth satellites are based on the NORAD SGP4/SDP4 code. This code produces the exact same output as their test collection. This means, however, that it is not

integrated particularly tightly with the rest of XEphem. For example, its computations use a different model for Earth flattening and for refraction. These and other differences can lead to modest inconsistencies.

5.1 Mouse functions

As long as the cursor is over the Earth, the four corners of the View will display the following information about the position beneath the cursor:

Upper left:	Latitude
Upper right:	Longitude
Lower left:	Local Mean Time
Lower right:	Local Sidereal Time

Middle button:

If View->Live dragging is On then while the middle button is depressed and located over the Earth map, the cursor is changed to a fleur pattern. Moving the mouse left and right is like moving the scale at the bottom; moving it up and down is like moving scale at the right. This provides a simple method to pan the display.

Right button:

If the right mouse button is depressed while over the Earth, a popup menu appears with information related to the location under the cursor as follows:

If the location is near a Site, information is presented with respect to the exact location of that site, otherwise it is with respect to the latitude and longitude of the location under the cursor.

If the location is near the current or a trailed location of one of the displayed objects, information is presented with respect to the location under the cursor and for that object at the time of the trail mark.

In either case, there will also be a button labeled Point that, if activated, will center the orientation on the selected location.

5.2 Control menu

Print...

This selection allows printing the current Earth view or saving it as a Postscript file.

Objects...

This brings up a window to control which of the User Defined Objects, OBJX, Y, Z, are displayed. See its own Help for full details.

Set Main:

This sets the Latitude and Longitude of the Main window to that of the current position of the Earth view. This also causes all other information and views to be updated to reflect the new location.

Set From Main:

> This sets the Earth view position to that of the Main window.

Movie Demo:

> This sets up an automatic display movie of the Earth. This is done by setting the N Steps entry in the Main window to a large value; setting the Step to 5 minutes; and starting XEphem looping. The movie can be stopped by selecting this option again or by selecting Stop from the Main window.

Close:

> This causes both the Earth view and the extra statistics window to be closed.

5.2.1 Objects dialog

This window allows you to display up to three objects on the Earth view simultaneously, with optional ground tracks.

There are three columns, one for each object. Click on an Option menu then slide and release over the desired object. The list will always contain the major Planets, Sun and Moon, as well as the three User Defined Objects, known as ObjX, Y, Z, if they are defined (see Main -> Data -> ObjXYZ for more information, §13.3).

Set Object:	ISS (ZARYA)	Moon	Moon
Display:	■	□	□
Label:	□	□	□
Trail:	□	□	□
Center:	◇	◇	◇
Popup Obj:	◇	◇	◇
SubLat:	10:05:34	−16:57:26	−16:57:26
SubLong:	−60:06:19	106:13:15	106:13:15
Alt(km):	380		
Range(km):	11484		
Range'(m/s):	−1604		
Sun lit:	0		
Age(days):	31.28		

11/25/2000 18:46:11 UTC

| Close | | Help |

Several controls and information values are available for each object as follows:

Display:

> This controls whether the selected object is shown at all. If it is visible, the object is drawn with a bulls eye pattern. Each circle of the bulls eye indicates the locus of points where the object appears in the sky 0, 30, 60 and 90 degrees from the zenith.

Label:

> This controls whether the name of the object is drawn above it current location.

Trail:

This control will bring up a window to define a ground track of the given object as it travels along its orbit. Each trail time is drawn connected with a solid line with each point indicated with a small mark. The time stamps shown with the trail, if any, are always in UTC.

Once a trail is defined, this toggle just turns the trail On or Off on the display. It will not bring up the Trail window again unless the trail gets deleted.

The trail will be deleted if the object is changed, or an Update occurs from the Main window while this toggle is Off. Creating a new trail will also delete the old one.

See the Help from the trail setup window itself for more details on how it operates.

Center:

As long as this toggle is On, the given object will remain centered in the display (to the extent possible). Only one object may be in control at a time. When all of these toggles are Off, the Earth view will remain fixed unless changed manually (via the Scales on the edges, setting from Main, or using the Mouse controls). This toggle is automatically turned off if any of these manual methods are used.

Popup obj:

This toggle selects the object to which the Button-3 popup's Alt/Az info refers, as seen from the current Main menu position.

SubLat:
SubLong:

The latitude and longitude of the ray connecting the object with the center of the Earth. These values are shown for all types of objects.

The following data are only available for Earth satellites:

Alt:

Height above sea level.

Range:

Distance from the Main location to the given satellite.

Range Rate:

The rate of change of the Range distance, with positive moving towards the Main location.

Sun lit:

1 if the given satellite is currently in sun light, else 0 if it is eclipsed.

Age:

> The difference between the current XEphem Main time and the epoch of the TLE orbital elements, in days. The larger this value, the more the satellite location will be in error. Errors depend on drag, maneuvers and initial state vector quality.

Each of these values may be used for plotting, solving and listing in the usual way (see the help items for these features). While looping with Pause set to 0, only the graphical display is updated (though numeric information is always updated internally each step).

If a User Defined object is set elsewhere in *XEphem* and an unused column is available it will automatically be selected and Center will be activated as a convenience.

5.3 View menu

Cylindrical
Spherical
Weather map

> These radio buttons select from several possible Earth projections.

> **Cylindrical**: Displays the entire Earth surface projected onto a cylinder. Primary advantage is the entire surface is visible at once. Particularly good for plotting satellite ground tracks. Major disadvantage is distortion near the poles.

> **Spherical**: Displays the Earth as it would really appear from space. The primary advantage is the sense of reality and lack of distortion.

> **Weather map**: Displays a global montage of satellite cloud imagery, ice, sea and land temperatures, courtesy Space Science and Engineering Center at the University of Wisconsin. The image is a gif file retrieved from `http://www.ssec.wisc.edu/data/comp/latest_cmoll.gif`. It is updated once every six hours. All other graphical features of the Earth view remain available as overlays to this image. Primary advantage is ease in determining whether weather will effect visibility of a satellite pass. If you have trouble accessing the image directly from XEphem, the program will also use the file `/tmp/latest_cmoll.gif` if it exists.

> The preferred width-to-height ratio for the cylindrical projection is 3.14:1. This ratio is enforced each time this projection is selected by changing the width and maintaining the current window height, subject to remaining fully on screen. Similarly, the spherical projection resizes to become a square by setting the width equal to the height. The weather map forces itself to become 640x480 pixels. After any projection is selected, the window size may be directly manipulated manually from then on as desired.

Reload map

> This button is only present when the Weather map projection is enabled. Pressing it will cause a fresh weather map to be retrieved.

Grid:

> This toggles showing grids lines every 15 degrees in latitude and longitude.

Sites:

This toggles whether a tiny square will be drawn at each location found in the currently loaded Sites file.

Sunlight:

This toggles whether the portion of the Earth's surface currently in sun light is highlighted in some fashion. When using the Weather map projection, the map is darkened where the Sun is currently down, and only cloud cover and continent outlines are shown.

Live dragging:

This toggles whether the display graphics are updated immediately as the sliders are moved, or whether graphics are only drawn after the sliders are released. Also, if this option is on, moving the mouse while holding down the middle button will cause the display to rotate about the pole when moved left-and-right or about a horizontal line centered on the window when moved up-and-down. If your system is sufficiently fast, the effect in quite dramatic.

6 Mars view
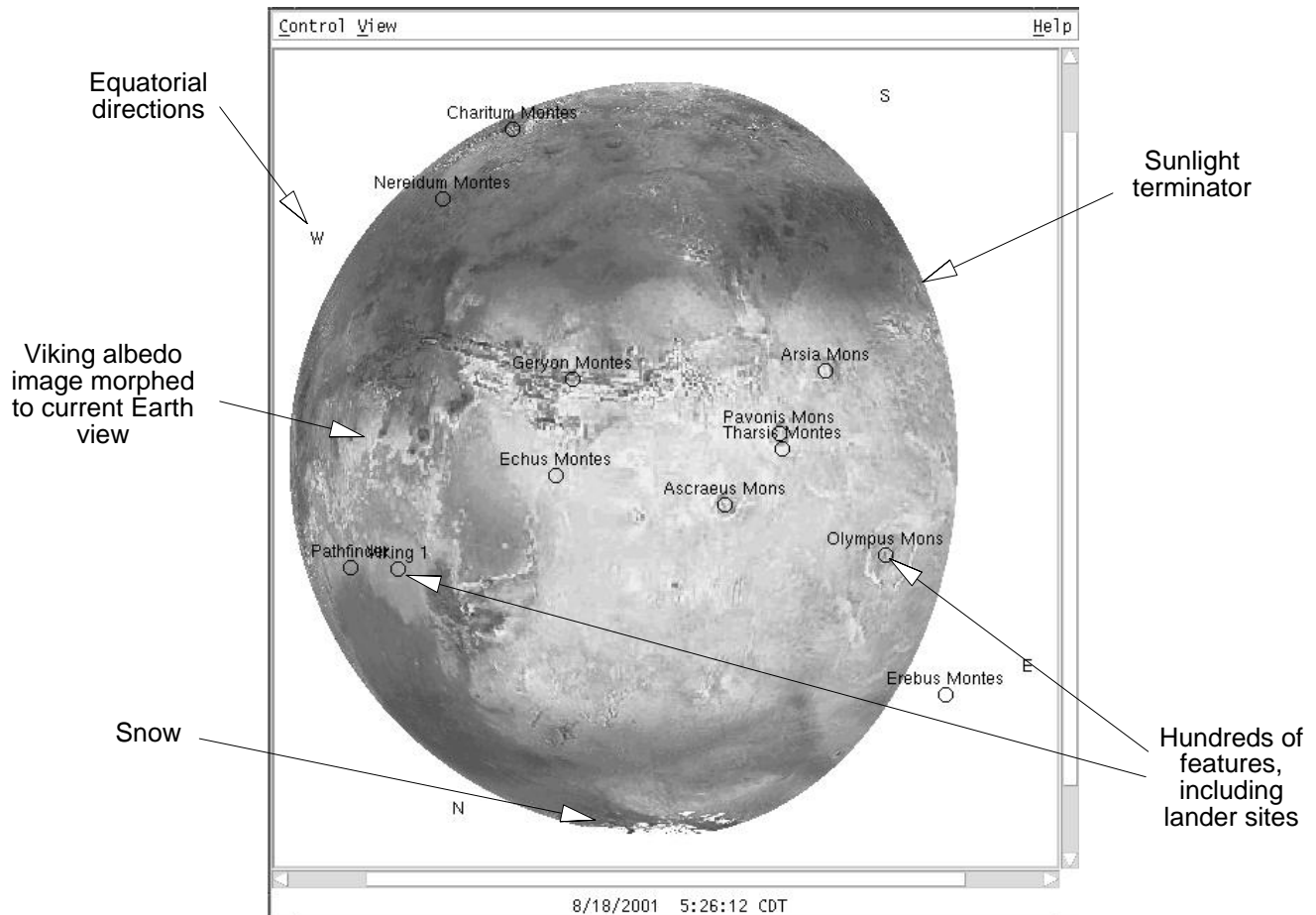
This window displays an image of Mars as it currently appears from Earth center. The resolution is 2/3 degree per pixel. The orientation is always parallel to the Martian rotation axis. The NSEW markings are directions on the celestial sphere.

6.1 Mouse functions

Left Button:

> If the View->More Info window is open, then moving the mouse around over the image while holding the left button will display the Martian latitude and longitude under the cursor location.

> A magnifying glass also appears attached to the cursor.

Right Button:

> Pressing the right button while over the planet will present a popup menu. Sliding down and releasing on the Point button in the popup will reposition the view so the current location is centered. This will also disable the shadow and the subearth marker until the next Update from the Main window. If over a feature, the popup will also contain its name,

type, diameter (or largest dimension) and location. If not over a feature, the cursor location is shown.

6.2 Control menu

Print...

This selection allows printing the current Mars view or saving it as a Postscript file (§14).

Close

This selection will remove the Mars view from the screen. If it is open it will also remove the More Info window.

6.3 View menu

Flip T/B

This sets whether the image is flipped top-to-bottom.

Flip L/R

This sets whether the image is flipped left-to-right.

Grid

This sets whether a coordinate grid is drawn over the image. Each line is spaced at an interval of 15 degrees. Also, unless the image has been repositioned by hand, an X marks the center of the image, that is, the subearth location.

Features...
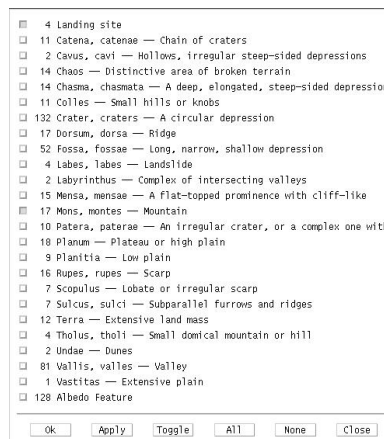
This brings up a separate window containing categories of surface features. Buttons across the bottom allow turning all features on, off or toggling. **Apply** puts the choices into effect, as will **Ok** which also closes the window.

More info...

> This brings up a separate window with additional Mars information and control capabilities. Please see the help from that window for more information.

Moon view...

> This brings up a separate window which depicts the two Martian moons. Please see the help from that window for more information.

6.3.1 More info dialog

```
Under Cursor:
Latitude +N:            9:05
Longitude +W:         263:14

Sub Earth Lat (+N):    24:00
[_____▭_____]

Central M Long (+W): 185:00
[_____▭_____]

Seeing (arc seconds):      0
[▭_____]

    11/25/2000 18:46:11 UTC

[ Apply ]  [ Close ]  [ Help ]
```

The top portion of this window reports the location of the cursor as it is moved over the image, if the left button is pressed.

The lower portion of this window shows the Martian latitude and longitude which currently face the Earth. These values are computed each time an Update is performed from the Main Menu.

Also provided is a scale by which you may set the size of your local seeing disk. The image will be blurred to roughly simulate the resolution under those conditions. The computing time will increase with larger seeing values.

For browsing purposes, the values may be changed as desired. Adjust any or all scales, then press Apply to put the changes into effect. Forcing changes in this way will also temporarily disable the shadow. At the time of the next Update, the correct current values and the shadow will be reinstated. The Apply button is made insensitive if the scale values are correct for the current time; the button becomes sensitive only when the scales have been moved manually.

The values in the lower portion may be used for plotting, listing and solving in the usual way as described in the Help entries for these Control options from the Main window. The values are always current when used in this way, even if the main Mars view is closed. For faster looping, close the main Mars display to prevent it from being redrawn each time.

6.3.2 Moon info dialog

```
Control View                    Help
              S
                            17
              ●
           .      .
                          E
           I      II


      ├──┼──┼──┼──┼──┤
              1'

      11/14/2000  7:56:07 UTC
```
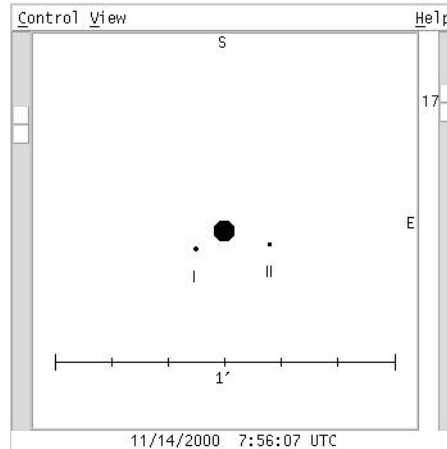
This is a schematic view of Mars and its moons at the indicated date and time. In addition, background sky objects may also be displayed.

The scale at the left controls relative magnification.

The scale at the right controls the dimmest magnitude which will be displayed. Mars is always displayed. The values range from 20 at the top and 0 at the bottom. Objects dimmer than the value specified are not shown.

Nominal celestial directions are indicated at the top and right edges.

Moons are displayed only if they are geometrically visible. Use the top view to see whether they are also in sun light.

6.3.2.1 Mouse functions

The mouse may be used to identify any object in the Mars view. Position the cursor near the object of interest and select the right mouse button. A popup menu will appear with the objects name, current location and magnitude.

6.3.2.2 Control menu

Field Stars...

This selection activates the Field Star setup window. For more information about this facility, see the Help for the Field Star window itself.

Telescope command:

This option causes the location of Mars to be sent to a fifo. The intent is for the fifo to be connected to a telescope control process.

This mechanism is the same as that provided by the Telescope facility within the Sky view. Please refer to its help for more details in §10.6 .

Movie Demo:

This option will set up the Main window time step controls for a 15 minute step size and start a loop which dramatically displays the motions of the moons as they orbit Mars. This selection automatically disables the View->Sky Background selection to insure reasonable speed. Push the button again to stop the movie.

Close:

This removes the Mars moon display, and the additional information window if present, from the screen.

6.3.2.3 View menu

Top view:

Selects whether to also display another window, looking down on the Mars system from above the N celestial pole. This window will tend to remain aligned above the main view when either is resized. Moons are displayed only if they are in sun light.

Sky background:

Selects whether to also show objects within the current field of view that are in the XEphem database memory or available from the Field Star facility. The size of the object is determined by the limiting magnitude as specified by the scale at the right. Objects are drawn using the same symbols as used by the Sky view. While this option is on, XEphem will continue to retrieve field stars as required.

Bright moons:

If this option is in effect, then the diameter of all moons will be increased by 3 pixels. This option also insures that even those moons which are dimmer than the limiting magnitude, as specified by the scale to the right, will be drawn with a circle of diameter 3 pixels.

Tags:

Search whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B:
Flip L/R:

These allow the scene to be flipped vertically and horizontally, respectively.

6.3.2.4 More info dialog

```
Under Cursor:
Latitude +N:          -21:52
Longitude +W:         114:08

Sub Earth Lat (+N):    24:09
[                  ▭      ]

Central M Long (+W):   74:44
[    ▭▭    ]

Seeing (arc seconds):      0
[▭                        ]

   11/20/2000  7:56:07 UTC

  Apply    Close    Help
```

This button brings up a separate window which contains quantitative information about Mars's moons. All values may be used in plotting, listing and solving.

The E and S columns are 1 if the moon is visible from the Earth and Sun, respectively.

The locations of the moons are given in two coordinate systems. The first three columns are the displacements of the moons in Mars radii with respect to the celestial plane. The next two columns give the RA and Dec location of the moons in the current epoch (as specified on the Main window).

7 Jupiter view

Pole View

South Pole

Sunlight
terminator

III

Orientation

I

II

to Earth

Earth View

Control View   Help

S

Galileo image
morphed to
current Earth view

Equatorial
orientation

Limiting
magnitude

Moon with
standard tag

E 10

III

Zoom

1′

Image
scale

8/20/2001 16:26:12 CDT
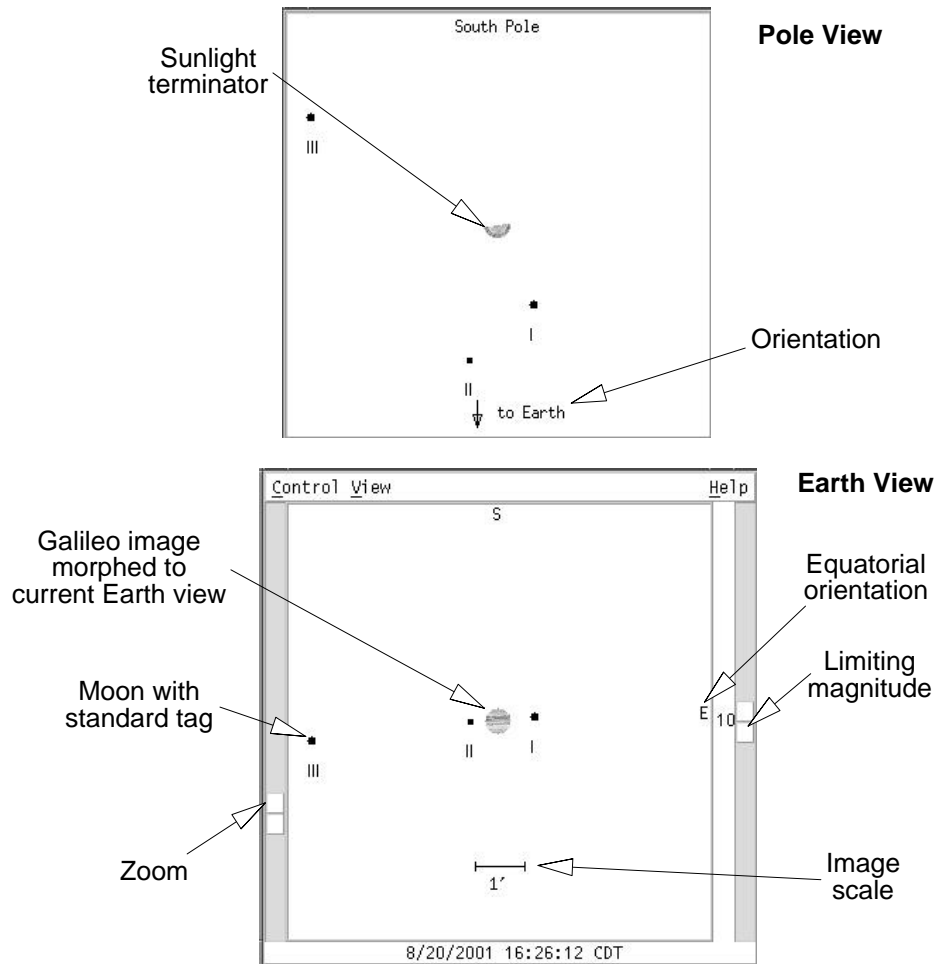
This is a view of Jupiter and its Galilean moons at the indicated date and time. In addition, background sky objects may also be displayed.

The scale at the left controls relative magnification.

The scale at the right controls the dimmest magnitude which will be displayed. Jupiter is always displayed. The values range from 20 at the top and 0 at the bottom. Objects dimmer than the value specified are not shown.

Equatorial directions are indicated at the top and right edges.

Moons are displayed only if they are geometrically visible from Earth. Use the top view to see whether they are also in sun light.

The default longitude of the GRS is set to 61 degrees, where it was in late May of 1997. This may be changed interactively in the More Info window.

7.1 Mouse functions

The mouse may be used to identify any object in the Jupiter view. Position the cursor near the object of interest and select the right mouse button. A popup menu will appear with the objects name, current location and magnitude.

7.2 Control menu

Print ...

> This selection allows printing the current Jupiter view or saving it to a file.

Field Stars...

> This selection activates the Field Star setup window. For more information about this facility, see the Help for the Field Star window itself)§13.4).

Telescope command:

> This option causes the location of Jupiter to be sent to a fifo. The intent is for the fifo to be connected to a telescope control process.

> This mechanism is the same as that provided by the Telescope facility within the Sky view. Please refer to its help for more details in § 10.6 .

Movie Demo:

> This option will set up the time step controls in the Main window for a 15 minute step size and start a loop which dramatically displays the motions of the moons as they orbit Jupiter. This selection automatically disables the View->Sky Background selection to insure reasonable speed. Push the button again to stop the movie.

Close:

> This removes the Jupiter display, and the additional information window if present, from the screen.

7.3 View menu

Top view:

> Selects whether to display another window located over the pole that is on top in the front view. This window will try to remain aligned above the main view when either is resized. Moons are displayed only if they are in sun light.

Sky background:

> Selects whether to also show objects within the current field of view that are in the XEphem database memory or available from the Field Star facility. The size of the object is determined by the limiting magnitude as specified by the scale at the right. Objects are drawn using the same symbols as used by the Sky view. While this option is on, XEphem will continue to retrieve field stars as required.

Bright moons:

If this option is in effect, then the diameter of all moons will be increased by 3 pixels. This option also insures that even those moons which are dimmer than the limiting magnitude, as specified by the scale to the right, will be drawn with a circle of diameter 3 pixels.

Tags:

Search whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B:
Flip L/R:

These allow the scene to be flipped vertically and horizontally, respectively.

7.3.1 More info dialog

```
                    Central Meridian Longitudes (degs):
    Sys I:    48.314                              Sys II:   73.915
                    GRS Sys II Long:    61
                    Moon Positions (Jupiter radii)
    Tag Name      E S  X (+E)   Y (+S)  Z (+front)    RA        Dec      Mag
        Jupiter  1 1   0.000    0.000    0.000     4:22:09.22  20:35:34.9  −2.9
    I   Io       1 1  −3.655    0.354   −4.657     4:22:03.31  20:35:26.3   5.0
    II  Europa   1 1  −4.619    1.150    8.063     4:22:01.75  20:35:07.0   5.3
    III Ganymede 1 1 −13.463    2.641    6.044     4:21:47.45  20:34:30.9   4.6
    IV  Callisto 1 1  10.752   −0.539   24.235     4:22:26.61  20:35:48.0   5.6
                    11/20/2000  7:56:07 UTC
                          Close
```

This button brings up a separate window which contains quantitative information about Jupiter's moons and central meridian longitude. All values may be used in plotting, listing and solving.

The E and S columns are 1 if the moon is visible from the Earth and Sun, respectively.

The locations of the moons are given in two coordinate systems. The first three columns are the displacements of the moons in Jupiter radii with respect to the celestial plane. The next two columns give the RA and Dec location of the moons in the current equinox (as specified on the Main window).

Value of the System II longitude of the Great Red Spot is displayed. The value may be changed according to current information. Pressing Enter will update the Jupiter display with the new value.

8 Saturn view

Pole View

Sunlight terminator

Orientation

Control View .... Help

Earth View

Zoom

15 — Limiting magnitude

E — Equatorial orientation

Moon with standard tag

1′ — Image Scale

8/20/2001 16:26:12 CDT

This is a schematic view of Saturn, its rings and moons at the indicated date and time. In addition, background sky objects may also be displayed.

The scale at the left controls relative magnification.

The scale at the right controls the dimmest magnitude which will be displayed. Saturn and its rings are always displayed. The values range from 20 at the top and 0 at the bottom. Objects dimmer than the value specified are not shown.

Nominal celestial directions are indicated at the top and right edges.

Moons are displayed only if they are geometrically visible. Use the top view to see whether they are also in sun light.

8.1 Mouse functions

The mouse may be used to identify any object in the Saturn view. Position the cursor near the object of interest and select the right mouse button. A popup menu will appear with the objects name, current location and magnitude.

8.2 Control menu

Print ...

> This selection allows printing the current Jupiter view or saving it to a file.

Field Stars...

> This selection activates the Field Star setup window. For more information about this facility, see the Help for the Field Star window itself (§13.4).

Telescope command:

> This option causes the location of Saturn to be sent to a fifo. The intent is for the fifo to be connected to a telescope control process.

> This mechanism is the same as that provided by the Telescope facility within the Sky view. Please refer to its help for more details in §10.6 .

Movie Demo:

> This option will set up the time step controls in the Main window for a 15 minute step size and start a loop which dramatically displays the motions of the moons as they orbit Saturn. This selection automatically disables the View->Sky Background selection to insure reasonable speed. Push the button again to stop the movie.

Close:

> This removes the Saturn display, and the additional information window if present, from the screen.
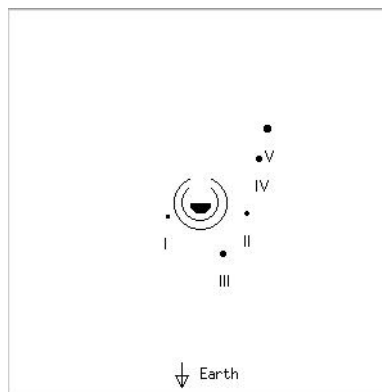
8.3 View menu

Top view:

> Selects whether to also display another window, looking down on the Saturnian system from above the celestial N pole. This window will tend to remain aligned above the main view when either is resized. Moons are displayed only if they are in sun light.

Sky background:

> Selects whether to also show objects within the current field of view that are in the XEphem database memory or available from the Field Star facility. The size of the object is determined by the limiting magnitude as specified by the scale at the right. Objects are drawn using the same symbols as used by the Sky view. While this option is on, XEphem will continue to retrieve field stars as required.

Bright moons:

> If this option is in effect, then the diameter of all moons will be increased by 3 pixels. This option also insures that even those moons which are dimmer than the limiting magnitude, as specified by the scale to the right, will be drawn with a circle of diameter 3 pixels.

Tags:

> Selects whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B:
Flip L/R:

> These allow the scene to be flipped vertically and horizontally, respectively.

8.3.1 More info dialog

```
                    Ring tilt (degrees, front +S)
From Earth: −23.550                            From Sun: −23.823

                    Moon Positions (Saturn radii)

Tag   Name       E S  X (+E)   Y (+S)  Z (+front)    RA          Dec       Mag
      Saturn     1 1   0.000    0.000     0.000   3:42:36.92  17:19:13.3   0.5
I     Mimas      1 1  −2.869   −0.308     1.035   3:42:34.97  17:19:16.4  13.0
II    Enceladus  1 1   3.835   −0.513     0.895   3:42:39.52  17:19:18.5  11.8
III   Tethys     1 1   1.804   −1.798     4.195   3:42:38.14  17:19:31.6  10.3
IV    Dione      1 1   4.844    1.477    −3.742   3:42:40.21  17:18:58.2  10.2
V     Rhea       1 1   5.588    2.577    −6.282   3:42:40.71  17:18:47.0   9.8
VI    Titan      1 1  −6.208   −7.433    17.774   3:42:32.71  17:20:28.9   8.4
VII   Hyperion   1 1  27.250   −0.445    −2.105   3:42:55.41  17:19:17.8  14.3
VIII  Iapetus    1 1 −12.162  −12.393    57.641   3:42:28.67  17:21:19.4  11.2

                    11/20/2000 16:56:07 UTC
                    [        Close        ]
```

This button brings up a separate window which contains quantitative information about Saturn's moons and its rings. All values may be used in plotting, listing and solving.

The E and S columns are 1 if the moon is visible from the Earth and Sun, respectively.

The ring tilt is displayed as the angle above or below the line of sight to Saturn from the Sun and the Earth. A positive value means the front of the rings are tilted southward.

The locations of the moons are given in two coordinate systems. The first three columns are the displacements of the moons in Saturn radii with respect to the celestial plane. The next two columns give the RA and Dec location of the moons in the current equinox (as specified on the Main window).

9 Uranus view

Pole View

Sunlight
terminator

Orientation

Earth View

Moon with
standard tag

Zoom

Image
scale

Limiting
magnitude

Equatoral
orientation

8/21/2001 23:26:12 CDT
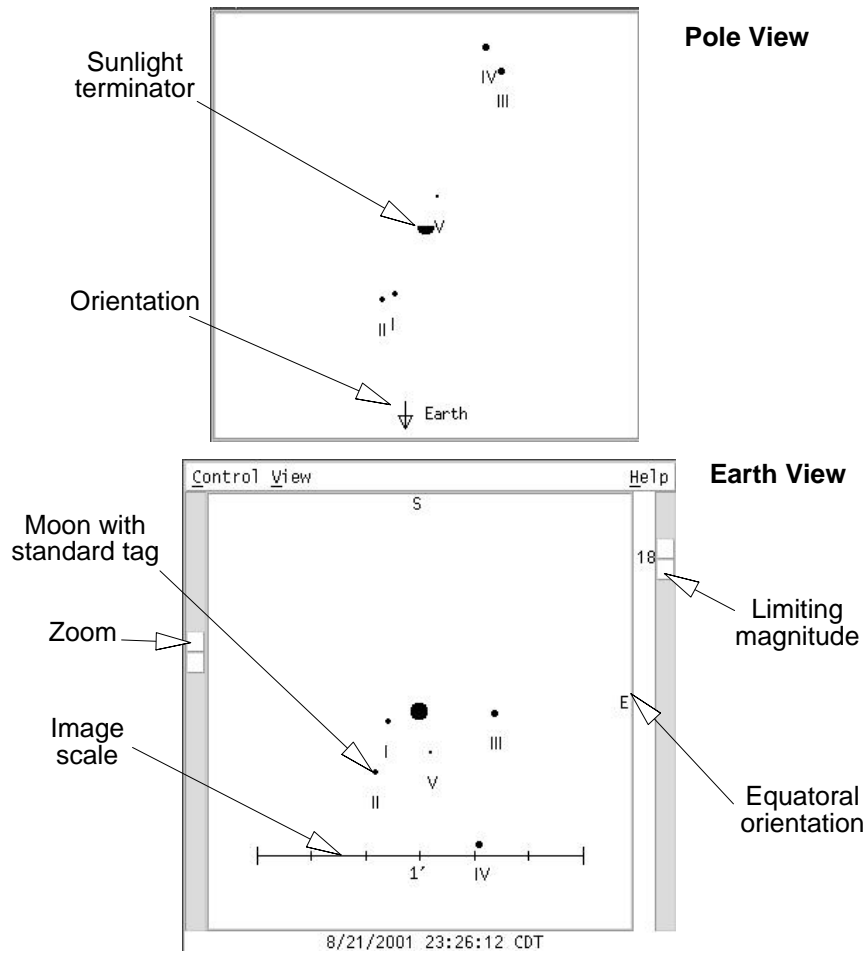
This is a schematic view of Uranus and its moons at the indicated date and time. In addition, background sky objects may also be displayed.

The scale at the left controls relative magnification.

The scale at the right controls the dimmest magnitude which will be displayed. Uranus is always displayed. The values range from 20 at the top and 0 at the bottom. Objects dimmer than the value specified are not shown.

Nominal celestial directions are indicated at the top and right edges.

Moons are displayed only if they are geometrically visible. Use the top view to see whether they are also in sun light.

9.1 Mouse functions

The mouse may be used to identify any object in the Uranus view. Position the cursor near the object of interest and select the right mouse button. A popup menu will appear with the objects name, current location and magnitude.

9.2 Control menu

Print ...

>   This selection allows printing the current Jupiter view or saving it to a file.

Field Stars...

>   This selection activates the Field Star setup window. For more information about this facility, see the Help for the Field Star window itself (§13.4).

Telescope command:

>   This option causes the location of Uranus to be sent to a fifo. The intent is for the fifo to be connected to a telescope control process.

>   This mechanism is the same as that provided by the Telescope facility within the Sky view. Please refer to its help for more details in §10.6 .

Movie Demo:

>   This option will set up the Main window time step controls for a 15 minute step size and start a loop which dramatically displays the motions of the moons as they orbit Uranus. This selection automatically disables the View->Sky Background selection to insure reasonable speed. Push the button again to stop the movie.

Close:

>   This removes the Uranus display, and the additional information window if present, from the screen.

9.3 View menu

Top view:

>   Selects whether to also display another window, looking down on the Uranus system from above the N celestial pole. This window will tend to remain aligned above the main view when either is resized. Moons are displayed only if they are in sun light.

Sky background:

>   Selects whether to also show objects within the current field of view that are in the XEphem database memory or available from the Field Star facility. The size of the object is determined by the limiting magnitude as specified by the scale at the right. Objects are drawn using the same symbols as used by the Sky view. While this option is on, XEphem will continue to retrieve field stars as required.

Bright moons:

> If this option is in effect, then the diameter of all moons will be increased by 3 pixels. This option also insures that even those moons which are dimmer than the limiting magnitude, as specified by the scale to the right, will be drawn with a circle of diameter 3 pixels.

Tags:

> Search whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B:
Flip L/R:

> These allow the scene to be flipped vertically and horizontally, respectively.

9.3.1 More info dialog

```
                    Moon Positions (Uranus radii)
Tag Name     E S  X (+E)   Y (+S)  Z (+front)     RA          Dec       Mag
    Uranus   1 1   0.000    0.000    0.000   21:19:18.31 -16:21:35.5  5.8
I   Ariel    1 1  -3.631   -5.103    4.917   21:19:17.91 -16:21:27.1 14.2
II  Umbriel  1 1  -2.604    8.439    6.724   21:19:18.02 -16:21:49.3 14.8
III Titania  1 1  -8.617    3.544   15.754   21:19:17.37 -16:21:41.3 13.7
IV  Oberon   1 1 -12.409   -1.678   20.991   21:19:16.96 -16:21:32.7 14.0
V   Miranda  1 1  -2.066   -4.485    2.261   21:19:18.08 -16:21:28.1 16.3

                     11/20/2000 16:56:07 UTC
                    ┌─────────────────────────┐
                    │          Close          │
                    └─────────────────────────┘
```

This button brings up a separate dialog which contains quantitative information about Uranus's moons. All values may be used in plotting, listing and solving.

The E and S columns are 1 if the moon is visible from the Earth and Sun, respectively.

The locations of the moons are given in two coordinate systems. The first three columns are the displacements of the moons in Uranus radii with respect to the celestial plane. The next two columns give the RA and Dec location of the moons in the current equinox (as specified on the Main menu).

10 Sky view
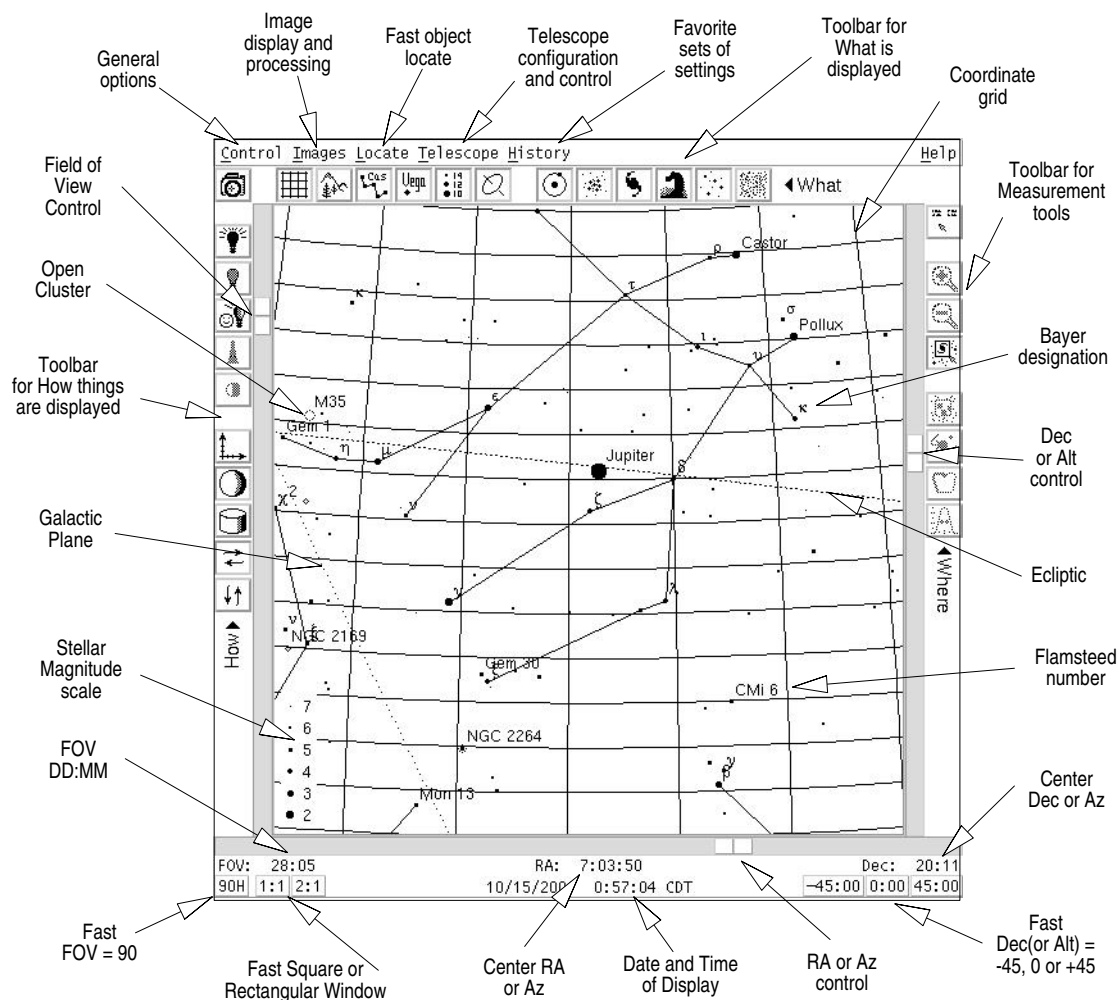
This window presents a schematic representation of the sky showing database objects and useful auxiliary information. A FITS file image can also be displayed simultaneously.

The dominant center area displays each object that meets the brightness and type filter selection criteria. A menu bar across the top offers access to all functions. Fast access to certain functions are available from the surrounding toolbars.

The mouse buttons can be used inside the display area for additional functionality specific to the exact location of the cursor when clicked.

Complete details on each control are found in the specific Help choices.

Note that while looping with Pause set to 0 the Sky View is not updated (although all quantitative information is always updated internally each step). This is to permit creating plots and using other XEphem features that use many time increments to run much more quickly if the Sky View is unmanaged or with Pause set to 0.

10.1 Toolbars

The toolbars are divided into three broad categories.

Down the left are choices that effect How the scene is portrayed, such as coordinate system, flipping and magnitude limits.

One magnitude deeper

One magnitude shallower

Automatic magnitude

Monument view (images only)

Brightness and contrast (images only)

RA/Dec or Alt/Az display coordinates (graphics only, images are always RA/Dec)

Spherical projection (graphics only, imags are always spherical)

Rectangular projection (graphics only, images are always spherical)

Flip left and right

Flip up and down

How

Across the top the choices effect What is displayed, such as coordinate grids, local horizon, and the classes of celestial objects.

◀ What

Display field stars

Display any stars[1]

Display nebulæ[1]

Display galaxies[1]

Display clusters[1]

Display solar system objects[1]

Display coordinate planes[2]

Display stellar magnitude scale

Display star names[2]

Display constellations[2]

Display horizon profile

Display coordinate grid[3]

[1] subject to settings in Control -> Filter

[2] subject to settings in Control -> Options

[3] matching display mode when turning On

All of the buttons in the Left and Top toolbars are just convenient shortcuts to functions that can also be accessed from the Options and Filter windows available in the Sky View Control menu. Please read the help for more information about these features.

The button in the upper left corner rather applies to both What and How:

Download DSS image

However, the toolbar down the right side is a little different. These buttons share a broad common theme of affecting, inspecting and deriving Where objects are located. Some also effect how the mouse operates. Because of their relatively complex nature, these toolbar buttons are best

described in their respective context so please see Help -> on Mouse and Image -> Processing tools for more information.

Display cursor coordinates in corners as mouse roams over display

Zoom in to region of interest (only when ROI is defined)

Zoom back to previous ROI (only when zoomed in at least one level)

Use mouse to draw Region of Interest

Mouse connected to magnifying glass (images only)

Mouse climbs to brightest pixel automatically (images only)

Mouse draws cross sectional slice (images only)

Mouse computes 2D Gaussian fit (images only)

10.2 Mouse functions

The mouse serves many purposes in the Sky View. Exactly what it does at any one time depends on whether it is located over an object and on the states of some of the toolbar buttons.

Idle:

Generally nothing happens when the mouse is over the Sky View and no buttons are being pressed. However, if the Roaming report toolbar button is On (upper right), basic data describing the position of the cursor are displayed in the upper corners whenever the cursor is over the Sky, even when no buttons are pressed. These data include:

Upper left corner:

RA, Dec and Hour angle equatorial coordinates;

the great-circle distance between the current position and the point at which the left button was last depressed;

constellation name;

raw image pixel coordinates, if displaying FITS image.
N.B. FITS coords are XEphem + 1

Upper right corner:

Alt, Az and Zenith distance horizon coordinates;

the volume and page number in the Uranometria, Uranometria 2000 and Millennium star catalogs.

NOTE 1: The coordinates are derived directly from the screen location and know nothing of the displayed objects. Thus, they neglect parallax (i.e., assume everything is at infinity).

NOTE 2: If the Telescope Marker is active and a telescope control process is reporting telescope position information, then when the cursor is outside the Sky View the data in the corners refer to

the telescope marker position, not the cursor position. This information is not displayed if any keyboard keys or mouse buttons are pressed.

Left button:

If the Roaming report toolbar button is On and the left mouse button is pressed, then the information in the upper left and right corners change into delta information, that is, the changes in the various coordinates with respect to the position where the left button was last pressed.

If the ROI toolbar button is On, pressing and dragging the left mouse button draws a Region of Interest box. This ROI can serve two roles. One is a way to zoom. Click on the ROI toolbar button then click in the Sky View with the left mouse button and begin to draw a box surrounding a region of interest. When the button is released, the ROI becomes fixed into position. To perform the zoom, press "Zoom In" in the tool bar (the round magnifying glass with a + within). The current size, position, and ROI are saved and the Sky View is changed to expand the new area. The "Zoom Back" tool bar button (glass with a - within) then becomes available to restore the display to its previous size and position. The Zoom In and Zoom Back buttons work as a pair for arbitrary levels of undo and redo.

This Zooming is implemented by actually sliding the scales around the edges of the Sky View just as if you had done it manually. Thus, the selected area may be rotated after the zoom due to a change in perspective in the map projection. This is a feature.

The other use for the ROI is available only when an image is being display. Basic statistics are computed for the pixels that lie within the ROI box and are displayed in the Images -> Processing tools window. See it's help for details.

Also only while an image is displayed, the left mouse button may be used to position a Magnifying glass; graph the pixels along an arbitrary cross sectional slice through the image; and compute and display high quality photometric and astrometric information about the star nearest the cursor based on 2D Gaussian fitting. All of these are describe more fully in the Help -> on Images section.

Middle button:

While the middle button is depressed, the cursor is changed to a fleur pattern. Moving the mouse left and right is like moving the scale at the bottom; moving it up and down is like moving the scale at the right. This provides a simple method to pan the display. This feature is not yet available while displaying an image.

If the "Live dragging" option is turned on (see Control -> Options), the panning occurs immediately. If this is painfully slow on your system then turn this off so the screen is only redrawn one time when the button is released.

Right button:

If the right button is clicked over the Sky View, then a popup menu will appear. If the button is clicked and released, the menu will stay up and can be used like any other menu. Or the button may be pressed and held while you slide the cursor to the desired button and let go. Try both and use whichever procedure you prefer.

The popup contains information and controls germane to the exact position of the cursor when the button was clicked. The entries in the popup menu vary depending on whether the cursor was near an object or over empty sky.

If the cursor is near a object, data is shown which are exactly the same as that which is available in the Data Table window; see its Help for more information. If a trailed object is selected, the data will be as it was at the time for that position. If the cursor was not near an object, basic information based on the location of the cursor itself is shown.

The popup also offers several control operations, as follows. At any one time, only the ones relevent to the current situation and toolbar choices will appear.

Center:

This will change the Sky View pointing direction to place the given object or location at the center of the field of view.

Center + Zoom ->

This will change the display orientation to place the given object (or location) at the center of the field of view and, at the same time, zoom in or out the amount selected in the pullright cascade menu.

Place eyepiece:

This will cause an eyepiece symbol to be drawn centered under the mouse location. The eyepiece shape and size is defined in the Eyepiece Setup window, available via Control->Eyepieces (§10.3.7).

Delete eyepiece:

This will delete the closest eyepiece covering this mouse location, if any. The search algorithm uses the smaller of the two dimensions of the eyepiece so it may be necessary to get close to the center depending on the shape.

New Photom ref:

This only appears if an image is being displayed, the 2D Gaussian image analysis tool is up, and the cursor was clicked near a database object. If all this is so, then said object is used as the new reference for photometric comparisons, and the magnitude of the object from the database is set as the reference for subsequent use.

Telescope GoTo

This will cause the coordinates of the cursor to be sent to a fifo, which is typically connected to a telescope control process. The command is not issued if the coordinates are below the horizon. This button is only present if the connected process is running. See Help -> on Telescope for more information.

AAVSO:

This will search the AAVSO database for the nearest objects and place them in the list of the AAVSO tool. See the Help for the AAVSO Tool for more information on downloading the light curve (§12.6).

Assign ->
  to ObjX
  to ObjY
  to ObjZ

> This cascade allows you to assign the given object to become ObjX, Y or Z, as desired (see §13.3). This will also cause all other views which are currently making use of this object to be updated and the object will be added to and selected by the Data table. Also, since this makes the object one of the User-Defined objects it will now appear directly in the Sky View->Locate pulldown menu.

Show in Data Table:

> This option is only offered when the object chosen under the cursor is a planet, the Sun or the Moon. Selecting this option forces the object to be enabled in the Data Table.

Persistent Label ->
  on Left
  on Right

> This cascade will toggle whether a label is drawn on the left or right side of the current object. The label will consist of the name and/or the magnitude, depending on which options are selected in the SkyView->Options Labeling section. If neither are selected, the label will consist of the name.

> Persistent labels are always on, that is, they are not subject to magnitude limits, options, or object type filtering.

> Note this option is maintained separately for trailed objects and for the untrailed objects; that is, you have independent control over labeling for a trailed object and its currently displayed object since the latter also always appears in the trailed list. This can be somewhat confusing for trails which begin "Now" since, in effect, the first item is drawn twice (once just because it is an object like any other, and again as a member of the set of trail history points).

Track:

> This will toggle object tracking for this object. If a trail object is chosen, the tracking will apply to the current position of the object. See the discussion for the "Tracking" toggle button for more details (§10.3).

Trail:

> This toggle is only present if the selected object has a trail defined. If it has a trail, the toggle state indicates whether the trail is being displayed. Note that turning off a trail does not actually discard the trail until the next Update occurs from the Main window.

Create Trail (or Change Trail) ...

> This pushbutton will bring up a window from which a trail may be defined, computed and displayed. The button is labeled "Change Trail" if the selected object already has a defined trail. Only one trail per object is supported.

10.3 Control menu

Options...

> This brings up a window with several choices effecting the way the scene is drawn. It has its own Help.

Filter...

> This allows selecting the types and magnitude ranges of objects to display. This window has its own Help.

Print...

> This allows printing the current Sky view or saving it to a file. If an image is currently being displayed, it will also be part of the print image. It has its own Help.

List...

> This brings up a window that allows saving the objects currently displayed in the Sky View to a file. It has its own Help.

Horizon...

> This activates the Horizon setup window. To display the Horizon profile, turn on the toggle under Option. For more information about this facility, see the Help from the Horizon window (§10.3.5).

Field Stars...

> This activates the Field Star setup window. To display Field Stars, turn on the toggle under Options. For more information about this facility, see the Help from the Field Star window itself (13.4).

Eyepieces...

> This brings up a window which allows you to specify the shape, size and style of the next eyepiece to be created. It has its own help. Whether eyepieces are shown at all is controlled by the Control->Options->Eyepieces option (§10.3.7).

Coordinates...

> This brings up a simple dialog which allows you to type in (or copy/paste) and convert among several common coordinate systems used in astronomy. A position defined in any of the coordinate systems can also be mark on the Sky View, which will be repositioned automatically if the position is not in the current field of view.

Tracking:

> Tracking here refers to "object tracking" and means that the pointing direction of the display will automatically be changed each time an Update occurs from the Main window such that the tracked object will remain centered on the display. The object to be tracked is selected by using the "Track" option in its popup menu, as described earlier.

> When this toggle button is sensitive and pushed-in it means that tracking is active for one object. The tracked object will be marked with an "X" on the display after each Update. If this toggle button is selected while it is sensitive, it turns tracking off. This is a convenient

alternate method to turn off object tracking without having to find the exact object being tracked and use its popup Track control.

When this toggle button is insensitive and popped-out, it means that object tracking is not active; it does nothing when selected while insensitive.

Close:

This causes the Sky view and all supporting windows to go away.

10.3.1 Options...

This is a description of the controls in the Sky Options window.

Note that some of these options are also available via the tool bars across the top and down the side of the Sky View. The top tool bar offers shortcuts to "What" is being displayed such as grid overlay, annotation, galaxies; the one down the left controls "How" it is displayed, such as brightness, display mode, flipping. To learn what each icon in the tool bars does, use Help->Context from the Main window and move the cursor over each icon to cause it to display its help tip bubble.
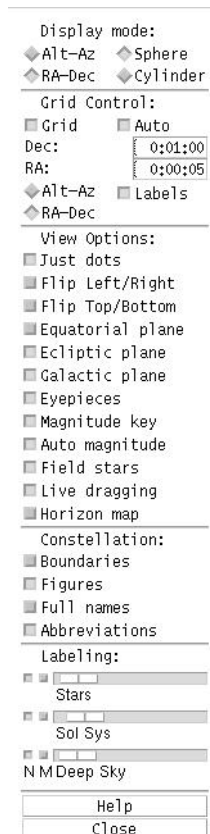
Display mode

Alt-Az:
RA-Dec:

This radio box selects whether the display coordinate system is Altitude-Azimuth or Right Ascension-Declination.

NOTE: While in Alt/Az mode the display is always topocentric; while in RA/Dec mode the display coordinate system depends on the Equatorial preference and Equinox settings in the Main window.

Sphere:
Cylinder:

This radio box selects whether the display is projected onto a sphere on a cylinder. The advantage of the sphere is that it mimics the real sky. The advantage of the cylinder is it shows the entire universe at once.

Grid Control

This group of controls allows you to specify the details of an overlay coordinate grid. **Grid** itself toggles the grid on or off.

If **Auto** is on, then the size of the grid steps will be determined automatically and shown in the text fields beneath; if it is off, then step sizes are determined from the values in the text fields. Typing into either field then pressing Enter will also turn off Auto and immediately display the grid with the new step size.

Alt-Az and **RA-Dec** selects in which coordinate system the grid will be drawn.

Label selects whether the grid will be labeled.

View Options

Just dots:

This toggle effects how stars are shown.

When the toggle is pushed in, all stars are displayed simply as dots of various sizes.

When the toggle is released, each type of star is displayed with a unique schematic symbol. These symbols may be reviewed from the Filter window.

In either case, the diameter of the symbol shown is the larger of the object's actual size at the current window scale (if a size is specified in the database entry for the object) or a size that is proportional to the difference between the object's magnitude and the current faintest magnitude setting.

This means that, at suitably small fields of view, the Sun and Moon are shown to scale. This is ideal for watching solar eclipses or occultations. For example, watch the solar eclipse over Hawaii by setting the date to July 11, 1991, time to 17:00 UTC, location to Latitude 19:50 Longitude 155:28, and starting a loop with a Step of 1:00 and Pause 1. Be sure to use the Alt-Az display mode to get topocentric positions or set the Main Preferences for Equatorial to Topocentric. It is also very handy to set to Track either the Sun or the Moon (whichever you wish to be centered during the movie).

Flip Left/Right:
Flip Top/Bottom:

> These toggle whether the display is shown with a flip in the left/right or the top/bottom directions, respectively.

Equatorial plane:

> This toggle selects whether a red 3:6 dashed line is shown along the Earth's equator projected onto the celestial sphere.

Ecliptic plane:

> This toggle selects whether a red 2:2 dotted line is shown along the ecliptic. The ecliptic is the plane of the Earth's orbit or, as seen from Earth, the path of the Sun and the approximate path of the planets across the sky. The anti-solar point is marked with a small open circle. The edges of umbra/penumbra of Earth are marked with open circles. If Preferences->Equatorial is set to Topocentric, the umbra/penumbra are projected at the current distance of the Moon and corrected for parallax; if set to Geocentric they are projected at infinity.

Galactic plane:

> This toggle selects whether a red 1:4 dotted line is shown along the galactic equator and small labeled +'s are placed at the North and South galactic poles.

Eyepieces:

> This toggle selects whether eyepieces are drawn on the Sky view, if and when any are placed. Eyepieces are placed on the Sky view by using the **Place eyepiece** control in the popup menu activated by the right mouse button. The shape and style of eyepieces is defined in the Control->Eyepieces window (§10.3.7). Eyepieces are only drawn if they fit entirely within the Sky View. This selection is automatically activated when an eyepiece is placed.

Magnitude key:

> This toggles whether to display a chart in the lower left corner showing the correspondence between dot size and star magnitude. The scale is automatically turned off each time an image is first displayed.

Auto magnitude:

> When this toggle is active, the faintest magnitudes and dot step size will automatically be set to something reasonable based on the field of view. This option is automatically turned on whenever the FOV changes for any reason, unless it was turned off manually.

Field Stars:

> This toggles whether field stars are automatically loaded and displayed if the position, field of view, limiting magnitude or time changes significantly.

> This selection turns itself off if any difficulties ever arise in retrieving field stars.

> See Control -> Field Stars -> Help for more info about field stars (§13.4).

Live dragging:

> This toggle button selects whether the graphics are redrawn in real time as the various scale controls are being slid, or whether the graphics are not redrawn until the mouse is released. The decision depends on the speed of the computer, display and data bandwidth. If the system is fast enough, turning this on can produce dramatic results.

Horizon map:

> This controls whether to overlay the local horizon profile on the Sky View and, when in Cylindrical + Alt-Az mode, whether objects below the horizon are drawn. The profile is drawn at azimuth steps of 1 degree.

> See Options -> Horizon -> Help for more information (§10.3.5).

Constellation

Boundaries:

> This toggle controls whether constellation boundaries are shown.

Figures:

> This toggle controls whether constellation figures are shown.

Full Names:

> This toggle controls whether full constellation names are shown. The names will be centered within the extent of the constellation figure. This control and Abbreviations can not be both on at once.

Abbreviations:

> This toggle controls whether abbreviated constellation names are shown. The names will be centered within the extent of the constellation figure. This control and Full Names can not be both on at once.

Labeling

> This portion controls labeling options. The three sliders select how many of the brightest objects to label in each of three categories. The label itself may consist of the Name or Magnitude or both, depending on which of the two buttons are depressed adjacent to each scale. If Names and Magnitudes are both enabled then the magnitudes are shown to the right of the name surrounded by parentheses. Magnitudes are shown to the nearest 1/10 with the decimal point removed.

Other labeling facts:

> Trailed entries do not contribute towards the brightest count.

> The Persistent Label option for individual objects is never disabled.

> Greek characters are used in Bayer names when YBS.edb is loaded (§13.1).

10.3.2 Filter...
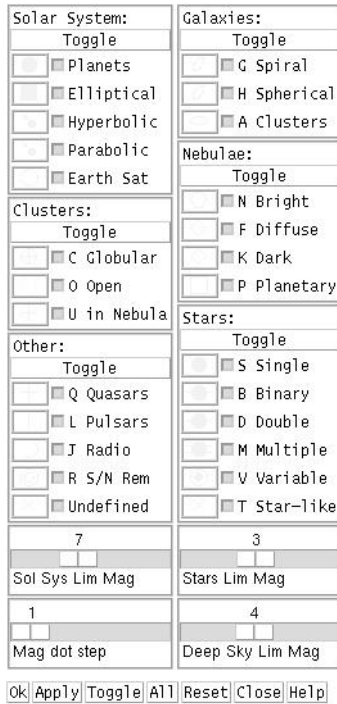
This window lists all classes of objects supported by XEphem. Using the Filter window, one may select which classes of objects are displayed on the Sky view window.

For reference, the Filter window also contains the schematic symbol for each type of object, and its code when used in a database file. The symbol displayed for each class of object is that which will be used to represent the object in the Sky view, unless "Just dots" is selected.

Three scales near the bottom of the Filter window control the faintest magnitude limit to be displayed for Stars, Solar system and Deep sky objects. Note that trails and persistent labels are not subject to the faint magnitude limits.

The fourth scale in the lower left selects the number of magnitudes binned in each dot size.

Several push buttons appear across the bottom of the Filter window which have the obvious effects: Selecting **Apply** updates the sky display according to the desired selection. Selecting **Ok** does the same thing but also closes the Filter window. **All** turns on all types. **Toggle** toggles each filter type.

10.3.3 Print...

This selection allows printing the current Sky view or saving it to a file. If an image is currently being displayed, it will also be part of the print image. It has its own Help (§14).

10.3.4 List...

This window lists, sorts and allows saving the objects currently displayed in the Sky View to a file.

Basing the list on the Sky View means the selection criteria uses the power of the Options and Filters controls as well as the region of the sky as defined by the center and field of view. If you wish to include all objects without regard to position, use the Cylindrical project mode, set RA-Dec, FOV 180, Dec 0 and resize the Sky View window to show the entire universe.

At the top, the format of the file created may be specified in either of two formats.

> The .edb format saves the objects in the XEphem catalog format. This is handy for using the XEphem filtering options to create custom catalogs.

> The text format is a columnar listing. The columns that are printed are the same as those currently selected in the Data Table, printed to the precision specified in the Preferences. A convenient button is provided to bring up the Date Table setup window. Note that a column need not be printed to be used for sorting, although it would seem unusual to do so.

The center section lists several fields that may used for sorting the list. Pick each field in the order you wish to sort the list. If you wish to make a change to the order, you may **Undo** one at a time back to the beginning or **Clear** the entire sequence and begin again.

The bottom section is a text field which (will) show the results of the sort. This text field is fully editable, so you may delete specific objects, add comments and so on as desired. N.B. If you have chosen the .edb format, no checks are made that your edits have made the format illegal.

Pressing the right mouse button over the text field will bring up a popup menu, if a valid object name is found at the beginning of the line under the cursor. This popup has buttons to Delete the object on the current line from the list and Mark the object on the Sky View.

Across the bottom are several controls:

Save

> This writes the text field exactly as it now appears to the file named at the right of the format checked at the top.
>
> N.B. No check is made that the format and the extension agree.

Sort

> This rebuilds the list according to the current settings. Use this after changing something in the Sky View, or after changing the format or sort settings here.

Close

> Closes this window.

Help

> Shows this help.

10.3.5 Horizon...


```
Choose method for specifying local Horizon

☐ Fixed displacement, Degrees above horizon:
0

☐ Horizon profile, map file name:
                Browse...
/home/ecdowney/.xephem/sample.hzn


        Close              Help
```

XEphem allows you to choose between two ways to display your local horizon.

One way, the simplest, is to define one altitude that will be used at all azimuths. To use this method, type the desired altitude in the field provided, then press Enter or toggle the button On.

The other is to create a file containing a table of the altitude and azimuth around your entire horizon. To use this method, type the name of the file containing the table in the text field provided, then press Enter or toggle the button On. The **Browse** button will bring up a File Selection Dialog for convenient interactive selection of available files if desired. This is handy if you find yourself setting XEphem to one of several different Sites and you have a horizon table prepared for each.

The Horizon profile file format (suffix .hzn) and its use by XEphem are defined as follows:

Each line should contain exactly two numbers separated by spaces. The first number is the azimuth, expressed as degrees East of North. The second number is degrees above horizontal. Lines of any other form are ignored.

The azimuth ranges from 0 up to 360 degrees. Any values outside this range have 360 added or subtracted until they fall in this range.

The lines need not be sorted by Azimuth, although they will be sorted when used; thus the horizon map can never cross itself.

If the file does not include the full range of Azimuths, the end points will be connected automatically.

It is ok to specify just one point (at any Azimuth). This will result in a flat horizon all the way around at the specified Altitude. (This is functionally equivalent to using the Fixed Displacement method).

Values in between those in the file are computed by linearly interpolating the two nearest surrounding points.

For example:

```
0   10
20  15
50  25
100 20
180 25
182 45
185 10
300 15
```

10.3.6 Field Stars...

This selection activates the Field Star setup dialog. For more information about this facility, see the Help for the Field Star dialog itself (13.4).

10.3.7 Eyepieces...

Width and Height
of next eyepiece
DD:MM

Moving either
W or H scale
moves both

Special case to
make next eyepiece
a Telrad pattern

Next eyepiece
Shape and Size

Angle subtended by
target on sky

Linear size of
target on
focal plane

Copy sky angle result
to eyepiece
W or H

Total effective
focal length

Apparent field
through eyepiece

Eyepiece focal
length

Primary mirror
focal length

Real field of view
on sky

Save current definition
in favorites list

Delete this definition
from favorites list

Width, height,
shape and style
codes

Use this
definition
next

Name for this
definition

Delete (only if at least)

```
Set next eyepiece size, shape and style:
W  2:25 [_____|___|_____]
H  4:02 [_____|___|_____]
☐ Lock scales together
☐ Create a Telrad pattern

Shape: ◇ Elliptical      Style: ◇ Solid
       ◇ Rectangular            ◇ Outline

Handy Field-of-View Calculators:
Focal Length   F Plane Size    Sky angle    Set
 (mm) m in       (μm) mm in     D:M:S
[50mm]         [35mm]          40:03:20.0   [ W ]
                                            [ H ]
Apparent  Eyepiece  Mirror FL
 FOV, °    FL, mm   (mm) m in                [ W ]
[45]      [12mm]   [2000mm]     0:16:12.0    [ H ]

Save Favorite Eyepieces:  [Add]
[Del][Use][My eyepiece #1]   0:50  0:50 E O
[Del][Use][My eyepiece #2]   1:04  2:25 R S
[Del][Use][My eyepiece #3]   2:25  4:02 E O

[      Delete all Sky View eyepieces      ]

      [ Close ]          [ Help ]
```

This window allows you to specify the shape, size and style of the next eyepiece marker to be placed in the Sky View. These markers are useful to show the view through your eyepiece, simulate the view of a CCD camera, or as simple annotation markers for any desired purpose. Symbology on the map will show through the eyepieces, even when they are specified as solid.

Note that this window controls the style of the next eyepiece to be created. To actually create an eyepiece, place the mouse over the Sky view where you want the center to be located and press the right button. A popup menu will appear. Slide down the menu and release over "Place eyepiece". See below for how to delete eyepieces.

Across the top are two sliders which set the width and height of the next eyepiece. These are shown in units of degrees:minutes. Below them is a toggle that will lock the two sliders so they move together. This is to make it easy to create eyepiece shapes that are perfectly round or square.

As a special convenience, there is a toggle which will create three open circles spaced to match the view through the venerable Telrad unit power finder. The circles are 0.5, 2 and 4 degrees in diameter. As long as this special toggle is pushed in, the other controls are made insensitive to avoid interfering with the preset values for the Telrad.

Next below are pairs of toggle buttons to select the Shape and Style of the next eyepiece. Elliptical and Rectangular refer to circles and squares. Solid and Outline refer to whether the shape will be filled in or just drawn as a border.

In the central portion of the Eyepiece window is a calculator that can be used to compute the sky angle of an optical system in two ways. The first method uses the net focal length of the entire

optical system and a linear size on the focal plane. The technique is handy for CCD users who want to find the sky angle subtended by each pixel. Another good use of this form is for photographers using film to find the amount of sky that will fit on their film. To cover this wide range of applications, the measures may be specified in any of several common units by adding the appropriate suffix. Default units are shown in parentheses.

The second method uses the apparent field of view while looking into an eyepiece and divides this by the magnification, which in turn is found from the ratio of focal lengths for the primary mirror and the eyepiece. Typical eyepieces provide about 45 degrees apparent fields of view, and some premium ones can go to 60 degrees or more.

After using either method, the resulting sky angle can be assigned to the width or height scale for the next eyepiece by using the Set W and H buttons to the right.

The bottom portion of the Eyepieces window allows you to save your most often used size, shape and style combinations. When these values are set as desired, press Add and they will be added as a new entry to the list. A simple name is chosen automatically but of course you can change this to be more meaningful to you. Each eyepiece may be deleted or put to use by using the buttons on the left.

To delete an eyepiece off the Sky View, place the cursor near it, press and hold the right mouse button, slide down and release on Delete eyepiece. After at least one eyepiece has been placed in the Sky View, a button at the bottom of this window will become available to erase all eyepieces from the Sky View. This is permanent. If you just want to temporarily turn all Eyepieces off and on use the Eyepieces option in the Control -> Options window.

Across the bottom are buttons to Close the window and get more information. Closing the window has no effect on existing eyepieces.

10.3.8 Coordinates...

This is a handy means to bring up the Main Tools -> Coordinate converter. Please see its own help for full details (§12.8).

10.3.9 Tracking

Please see the description for this button in the discussion for the Sky View Control menu (§10.3).

10.3.10 Close

This causes the Sky view and all supporting dialogs to go away.

10.4 Images Menu

This menu controls Sky View's image display capabilities.

10.4.1 Load and Save
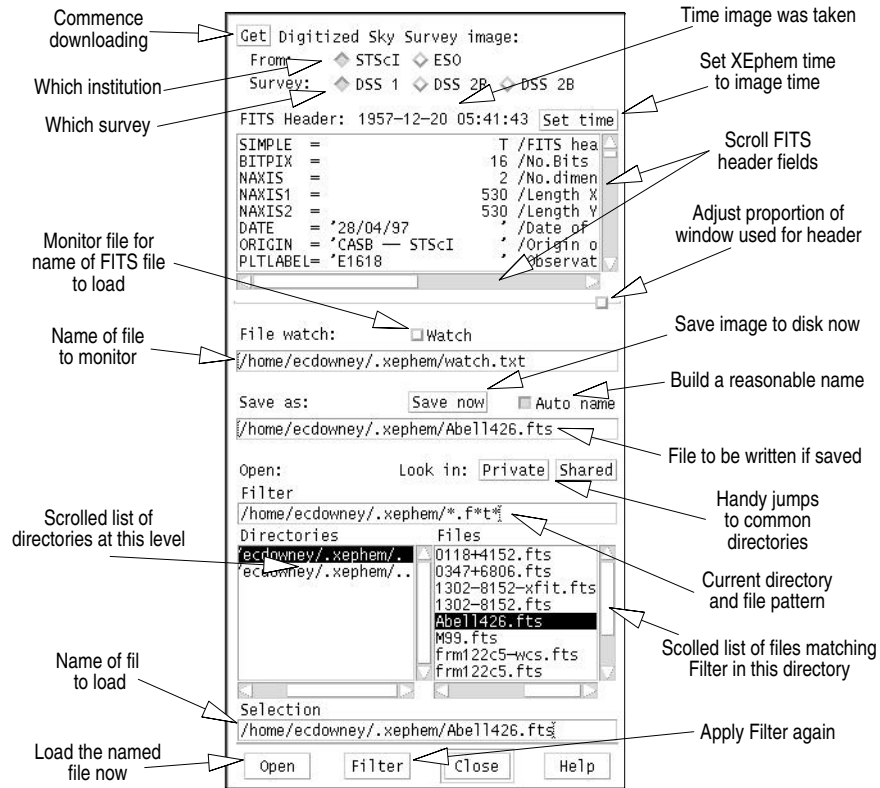
This window allows you to display a FITS file in the Sky View window. You may display local files or download the Digital Sky Survey directly from the Internet. The image is resized to match the size of the Sky View window.

Once an image is displayed, all graphical features of the Sky View are available, such as grids and labeling objects loaded in the XEphem database. Most of these features require that WCS headers be present in the image. XEphem can help create these using the Images -> WCS Solver tool.

This window contains several sections. Each is described below. Also notice the tiny square box just to the lower right of the FITS Header box. This is a pane control with which you may adjust the proportion of window real estate used by the FITS box. Of course, you can also increase the total size of the window as well.

Get

This button heads up the section for downloading images from the Net. You may choose DSS generations 1 and 2, and either Red or Blue filters for the latter.

The DSS is maintained by the Space Telescope Science Institute, STScI, in the United States or the European Southern Observatory, ESO, research facility in Germany. The image data from either site is identical, so choosing which to use depends only on availability and whichever is faster for you. The size and position of the image are that of the current Sky View settings, but the size limited to 30 arc minutes by agreement with each institution.

Before attempting a download, use the File -> Network setup window off the Main menubar to configure your Internet connection.

Pressing Get will begin the download. A progress meter will display remaining time. A Stop window is provided if you care to abandon the effort. The header of the http server response message is in the Main File->Log window; check there if an error occurs.

FITS Header:

This section consists mainly of a scrolled text area which shows each field in the FITS header.

If the header contains any of the fields EPOCH, JD or DATE-OBS then the date of the observation is displayed above the header. A button will also come alive which allows setting the main XEphem time and date to this value. This is handy when checking for asteroids, comets or using the proper motion catalogs with an image.

In order to be displayed, the header in a FITS file must contain at least the mandatory fields SIMPLE, BITPIX, NAXIS, NAXIS1, NAXIS2 and END. Only files with BITPIX 16 and NAXIS 2 are supported. Both DSS PLATE headers and the traditional World Coordinate System fields CTYPE, CROTA, CRPIX, CDELT and CRVAL, 1 and 2 are supported. BSCALE and BZERO are not support at this time.

Caveats:

XEphem treats the 16 bit pixels as unsigned values from 0 through 65535, unlike the standard which specifies they be treated as signed with values from -32768 through 32767. XEphem assigns the coordinate [0,0] to be the center of the first pixel in the file, unlike the standard which specifies this position be at coordinate [1,1].

File watch:

This feature allows XEphem to automatically display FITS files that were created by another program. All that is required is to arrange for that program to write the path to the new file to the file named in the text field provided here. When Watch is turned on, XEphem will try to open this file on a regular basis and read the first line. If successful, the file is displayed and, as a simple handshake to the originating program, XEphem removes this communication file.

With this feature and the popularity of various networked file systems (NFS, Samba, etc) it is quite reasonable to display images with XEphem that were captured on an entirely different computer. Or even on the same computer to use camera control software entirely unrelated to XEphem.

A further note to implementors: XEphem also supports this file being a fifo. In this case, XEphem will open the fifo and block trying to read a path name up to the first newline. There is no handshake in this case. The fifo approach is actually a bit more efficient than the file approach because no polling is required.

Save as:

The image currently displayed, if any, may be saved to disk as a FITS file. The file name is specified in the text field provided. If "Auto name" is enabled, a filename is automatically created derived from the RA and Dec of the center of the image. An attempt is made to preserve any existing directory and filename extensions, such that the filename is constructed between the right-most '/' and the right-most '.' characters, if possible.

When an image is saved, its current contrast settings are added to the FITS headers. If these fields are present when the file is opened these settings will automatically be put back into effect. See the Help for Images -> Processing tools for details.

Open:

This section is the way to open a local disk file for display. Use the File Selection Box at the bottom to choose the desired file. Browse your file system using the Directory and File lists, then double-click on the desired file. Or the file name may be typed (or pasted) into the Selection text field after which you click Open.

You can browse to any directory on your system (for which you have suitable permission of course) but there are two convenience buttons on the right that are particularly handy. One jumps straight to the system-wide Shared XEphem directory, and the other jumps to your per-user Private directory.

The Filter text field can contain the path and a wild card pattern to match the names of FITS files on your system. The default pattern is suitable for most case; it filters for any file extension that begins with f and contains a t in any subsequent position. When a new Filter is entered, click the Filter button at the bottom to apply the pattern to the directory currently chosen.

10.4.2 Processing tools...

```
Abell426.fts 530W x 530H
  Max: 47620    at:  33, 93
  Min: 35559  Mean:  36792.1
Median: 36498 StDev:   1179.2
Help □ Brightness and Contrast
Help □ Cross section Slice
Help □ Magnifying Glass
Help □ Region of Interest
Help □ 2D Gaussian Measurements
     Close        Help
```
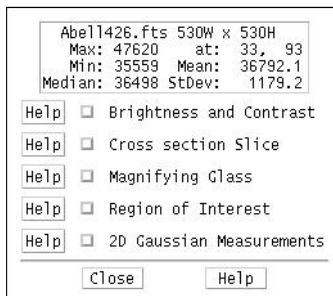
The Sky Image Tools window offers several functions with which to analyze the FITS file showing in the Sky View. There are a few sample FITS files included with which to practice using the tools.

The window is divided into several separate sections, each of which can be opened and closed as desired. Please see the Help for each section for specific information on each.

Always present at the top of the window is a block of basic information about the image. This includes:

file name;
width and height;
value and location of brightest pixel;
value of dimmest pixel;
mean, median and standard deviation of all pixels.

Two Important Differences between XEphem and FITS:

1. XEphem treats the 16 bit image pixels as unsigned values from 0 through 65535, unlike the FITS standard which specifies they be treated as signed with values from -32768 through 32767.

2.   XEphem image coordinates are one less than the FITS standard. FITS defines the center of the first pixel in the file to be at [1,1] while XEphem defines it to be at [0,0].

10.4.2.1 Brightness and Contrast

Help for this section

Black stars

Shortcuts

Numeric black and white pixels

Gamma scale

Histogram

Brightness assignment

```
Abell426.fts 530W x 530H
  Max: 47620    at:  33,  93
  Min: 35559  Mean:  36792.1
Median: 36498 StDev:   1179.2
```

Help ▢ Brightness and Contrast

▢Reverse Sharper Brighter
Nominal   Duller   Darker
Narrow   Wide   Full
Low 35612 ... 39150 Hi
      0.75

Help ▢ Cross section Slice
Help ▢ Magnifying Glass
Help ▢ Region of Interest
Help ▢ 2D Gaussian Measurements
     Close   Help

This section controls the mapping between image pixels and screen colors. It does not modify image pixels in any way.

This section may be opened using the button in the left Sky View toolbar that looks like a circle filled with black on the right half.

The top nine buttons offer shortcuts to set or adjust the image appearance according to predefined algorithms.

Reverse: toggles between assigning brightness in direct or inverse proportion to image pixel values.

Narrow, Wide and Full correspond to high, medium and low contrast settings. These are implemented using increasingly broader assignments of brightness about the mean pixel value in the image. Narrow assigns full black and white to the mean ± 1/3 Std Dev. Wide assigns black to mean - 1*StdDev and white to mean + 2*StdDev. Full assigns black to the smallest pixel and white to the largest pixel in the entire image.

Sharper and Duller change contrast by changing the slope of the pixel-to-brightness map to be steeper or flatter.

Brighter and Darker change the brightness by shifting the center of the pixel-to-brightness map to higher or lower pixel values.

Nominal ignores the statistical distribution of pixel values and sets the map entirely on the basis of the minimum and maximum pixel.

Below the buttons are text fields in which one may type (or paste) the exact pixel value to be assigned to black and white. They always show the current settings. A new value takes effect when Enter is pressed.

Below that is a scale to adjust Gamma. The mapping from pixels to display colors is a power function similar to the Gamma factor for CRT compensation. Values of gamma less than 1 emphasize dark pixels, gamma values greater than 1 emphasize bright pixels.

The graph contains two overlaid plots. The horizontal axis for each plot is the same: the full range of pixel values within the image, with lowest on the left. The orange line is a histogram of the number of pixels with each value. The yellow line indicates the brightness at which each pixel value will be displayed on the screen. You may control the black and white limits of the mapping function from the graph by dragging the red arrows at the top of the diagram. You may control gamma by sliding the scale ust above the graph.

When XEphem saves an image, it adds three fields to the FITS header to save the current contrast settings. When it loads an image, if these fields are present they are used to restore the same display contrast. If these fields are not present, the Wide setting is used. These fields are:

XELOGLUT: the pixel value assigned to black

XEHIGLUT: the pixel value assigned to white
XEGAMMA: the value of Gamma.

10.4.2.2 Cross Section Slice

Opening this section lets you use the mouse to drag a line across
the image and display the pixels along that line. The graph is
labeled vertically in pixel value, horizontally as pixel distance from
the starting point. The line begins where the left mouse button is
first depressed.

This section may also be opened using the button in the right
Sky View toolbar that looks like a slice of bread.
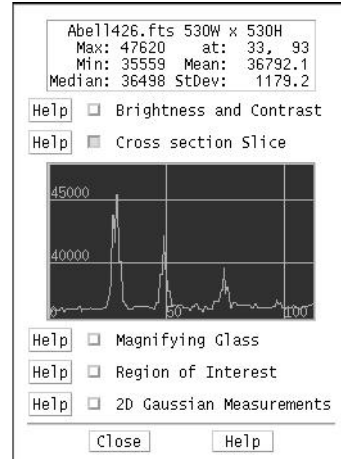
10.4.2.3   Magnifying Glass
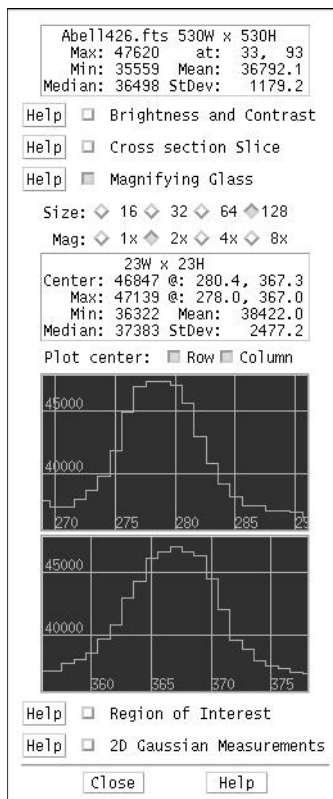
This section gives control over and
shows information about the pixels
in the magnifying glass.

Click and hold the left mouse button as you roam over the image
and you will see an expanded view of the pixels. The Size and
Magnifying power of the glass can be set as desired using the two
rows of toggle buttons. Note the numbers on these buttons are in
units of screen pixels, not image pixels. So for example if you
zoom in on an area the magnifying glass will expand it
correspondingly further.

While roaming you might want to turn on the Jump to Max
button on the right hand toolbar. It is the one with the bright
dot in the center to which a meandering arrow finally points. When
this button is on, XEphem will begin at the pixel under the real
cursor and walk the gradient to the brightest connected pixel. All
processing proceeds as though this brightest pixel is where the
cursor really pointed.

Statistics about the image pixels under the glass are shown in the
table. All values are in pixels, all locations are in image
coordinates. Fractional image coordinates occur because the
image is resized to fit the window which results in rational values
for the scale factors. If you zoom in enough to clearly see
individual image pixels, you can see that the coordinate system for
image pixels puts the integral position in the center. The statistics
in the table include:

Size of the area under the glass;
Value and location of the center;
Value and location of the largest pixel under the glass;
Value of the minimum pixel;
Mean value of all glass pixels;
Median value of all glass pixels;
One Standard Deviation of the pixel values about the mean.

Below the statistics box you can optionally open windows that plot the row or column through the center of the glass. The horizontal axis of each graph is in image pixels, the vertical is in image pixel values.

This section may also be opened using the button in the right Sky View toolbar that looks like a box containing a few stars much larger than the others. However, since the glass is useful in its own right, the toolbar button only opens this section if the Image Tools window is already up. Similarly, closing this section does not also turn off the toolbar button.

10.4.2.4 Region of interest

This section lets you use the mouse to draw a rectangle over the image and get statistics about the pixels within this region. (The area is the same one that can also be used to specify a region in which to zoom in upon.)

This section may also be opened by the right toolbar button that looks like the curson has just drawn a box around a galaxy.

The following statistics about the image pixels in the ROI are shown in the table:

> Length of the diagonal;
> Width and height of the region;
> Value and location of the cursor as you draw the ROI;
> Value and location of the largest pixel in the ROI;
> Value of the minimum pixel;
> Mean value of all glass pixels;
> Median value of all glass pixels;
> One Standard Deviation of the pixel values about the mean.

10.4.2.5 2D Gaussian Measurements

This section is based on results of modeling stars with a 2 dimensional Gaussian. The model finds the coefficients in the following function of pixel coordinates x and y that minimizes the squared error with each pixel in an area:

$g(x,y) = B + A*exp(-0.5*(sqr((x-mx)/sx) + sqr((y-my)/sy)))$

where
 mx is the row coordinate from some reference position,
 my is the same for a column,
 sx is the standard deviation of the pixel values along a row,
 sy is the same for a column,
 A is the peak height of function (= g(xm,ym) - g(inf,inf)),
 B is the mean of the row and column pixels.

[mx,my] is then taken to be the location of the star, the volume as proportional to A*sx*sy as a measure of its magnitude, and B a measure of the mean noise level of the surrounding pixels.

In practice, we find this method converges quickly and yields positional results accurate to .2 pixel or so. Magnitudes and their error estimates depend strongly on whether the image was ever compressed, proper image cleanup, nonlinearity of ADU counts with brightness, and other

factors. When these factors are properly addressed, magnitude ratios seem to be good to .02 mag or so.

Back to the GUI... the text box shows the results of this fitting process on the image pixels that are centered on the cursor and lie within the area defined by the magnifying glass settings (whether or not the glass is actually turned on). The numbers report the following:

> Relative magnitude difference and error estimate between the current star and the reference star;

> Position of the star, in image coordinates and in RA/Dec if WCS header fields are present;

> Full-width-half-max of the star in each dimension in pixels and in arc seconds if the image scale is known from header fields CDELT1 and CDELT2;

> The pixel value representative of the noise level base in the area (B in the above equation);

> The pixel value of the peak of the Gaussian fit (A+B in the equation).

If there is a number in the Reference Mag text field, it is simply added to the magnitude reported. The idea is to set this to the magnitude of a star (known by independent means) and use that star as the reference for subsequent comparison. Since the reference is now calibrated, magnitudes reported will be "absolute" not just relative. Except under special situations, the reference star will not be applicable to other images, although XEphem does not prevent you from doing this.

The reference star can be established in a few ways. One way is automatic in the sense that if there is no current reference, the first star that is measured is also automatically given the role as reference for subsequent comparisons. After any star has been measured, it can be made the reference by clicking on New. Clicking Mark will draw a small circle in the image around the current reference star.

Another way to set the reference is to use a catalog star. This is only possible, of course, if the header includes WCS coordinates. Right-click on the catalog star and choose the entry "New Photom ref". This will perform the Gaussian fit on the pixels at that stars location in the image, and assign the Reference Magnitude to the catalog value.

This section of the Sky image tools window can be opened by clicking on the button in the right toolbar that looks like a Gaussian graph (or perhaps a large nose).

While measuring stars you might want to turn on the Jump to Max button on the right hand toolbar. It is the one with the bright dot in the center to which a meandering arrow finally points. When this button is on, XEphem will begin at the pixel under the real cursor and walk the gradient to the brightest connected pixel. All processing proceeds as though this brightest pixel is where the cursor really pointed.

10.4.3 WCS Solver

This window controls a pattern matching algorithm that attempts to register the star-like artifacts in a FITS image with the entries in any or all of the XEphem Field Star catalogs, currently including the GSC, USNO, PPM and Tycho star catalogs. The choice of catalogs is controlled by the Control -> Field stars window.

```
RA, H:M:S        03 19 42.000    Use field:   OBJCTRA
Dec, D:M:S       +41 30 00.00    Use field:   OBJCTDEC
°/Pixel right    -0.000471976    Use field:   CDELT1
°/Pixel down     0.000471976     Use field:   CDELT2
Rotate °EofN     -2.01406        Use field:   CROTA2
Burned out:      60000           S/N ratio:   5.0
Max pix acc:     0.2             Min pix acc: 1.0

     Close          Go          Mark stars      Help
```

Rows 1-5: setting seed values.

> The first five rows seed the search with approximate coordinates for the center of the image, the scale of the image pixels in each direction, and a possible rotation. The center must be known to within about one half the smaller of the image width and height. The scale must be known to within about 10%. The rotation seed need not be accurate at all, but better estimates will result in vastly faster solution times. Indeed, better values for any field will improve the solution speed and also reduce the chances of a false solution.

> Each of the fields may be typed or pasted into the fields down the left. But often FITS files will include fields which contain information suitable for this purpose. In the column down the right you may enter the names of such fields. Clicking the "Use field" button in a row will read the value from the header field named on the right and install it into the field on the left of the same row, possibly after some reformatting and change of units. Certainly not all forms are supported so please take care to check for proper units and formatting yourself. The default fields supplied are fairly common and are known to work if you are lucky enough to have them in your images.

Row 6: scanning the image for star-like artifacts.

> The next row contains two parameters which control the algorithm that scans an image to extract what seem to be reasonable candidates for stars, that presumably will also be in a Field star catalog.

> Burned out: This parameter sets the largest pixel value (in the range 0 .. 65535) a star may contain. Groups of pixels being considered as a candidate star by the algorithm will immediately reject the entire group if even one pixel is higher than this. The idea here is that if a star is so bright as to be even a little burned out, its centroided position is likely to be worse than not using it at all. If you feel otherwise, set this to 65535 and no groups will be rejected (at least for this reason).

> S/N ratio: This parameter sets the minimum signal-to-noise ratio of a candidate star. The algorithm breaks an image into several smaller regions and computes several statistics of all the pixels in that region. In order for a group of pixels to be considered a star, its brightest pixel must be at least the median plus this parameter multiplied by the standard deviation computed from the statistics of the region in which it is located. Basically, the larger this number, the more distinct the star must be.

Row 7: Setting realistic search goals.

> The bottom row contains two parameters that effect the goal of the search algorithm.

> Max pix acc: This parameter tells the search algorithm not to expect position information for the star-like artifacts extracted from an image to be any better than this fraction of a pixel.

> Min pix acc: This is the worst pixel distance acceptable between each image star and its closest catalog star.

Close

> Closes this window.

Go

> Commences the search for a solution using the image currently in the Sky View and the parameters in the various fields above.

> If a solution is found, each star used in the solution will be circled and statistics about the quality of the solution will be presented. The WCS fields that characterize the solution are written into the FITS header. If you like the solution, Save the image and this search will not be needed again.

Mark stars

> Clicking this button will draw a small circle around each group of pixels in the image the algorithm considers to be a star. Use this to choose good values for Burned out and S/N ratio.

Help

> Show this text.

10.5 Locate menu

This selection will pop up a list of the basic objects and the currently defined user objects, if any. Selecting an entry will place a cross-hair over the object. If the object is not within the field of view the Sky View will be moved so the object is centered. If Alt-Az mode is currently active and the object is below the horizontal the view will not be changed and a message will suggest the mode first be changed to RA-Dec.

To aim the Sky View at any other object in the XEphem database, please use Main -> Data -> Search.

10.6 Telescope menu

The Telescope menu in Sky View allows you to control any GOTO-type telescope that is compatible with the venerable Meade LX200.

Clicking on the top item in this menu will bring up a window for configuring and controlling the telescope connection. Please see its own help for full details (§10.6).

Once XEphem is operating the telescope correctly, it is commanded to a target by positioning the cursor at the desired location in the Sky View, press and holding the right mouse button, and sliding down and releasing on Telescope GoTo.

Each time this action is performed the target name (or RA-Dec coordinates, if sent to an empty sky location) is added to this Telescpoe menu. To command the telescope to the same target again, just slide down and release on its entry. The list will grow until erased using the Erase history button.

10.6.1 Telescope configuration

This window is for configuring an LX200 connected to a serial port of the computer running XEphem. There are just a few fields to be filled out.

Version 3.5.2

Control process:

> This field names the driver program that does the real work. The name lx200xed is the one for the LX200 command set. This should not be changed unless a new driver has been supplied.

Serial device:

> This is the name by which your operating system designates the RS232 serial port connected to the telescope. The default will be close for a typical installation. See the chapter in the manual for more information about specific operating systems.

Show Sky View marker

> Once the telescope is working under XEphem's control, a circle-X marker will be drawn on the Sky View to indicate its current position. XEphem keeps this marker within the Sky View field of view at all times, and will reposition the Sky View if necessary to achieve this. On occasion this behavior can be annoying, such as when you wish to use the Sky View for something not immediately related to the operation of the telescope. In this case, turn the marker off with this button, and back on later as desired.

Enable Telescope GoTo

> This button controls whether the various controls throughout XEphem that command a telescope to move are in fact active. These controls appear in the popup menu in the Sky View, and in the various planetary closeup windows. If you prefer these controls are disabled, click this button off.

> Another reason for this button is for those users of XEphem who have built their own telescopes with only encoders and no motors. With a suitable driver, XEphem can then show the location of the telescope in the Sky View, even though it can not command motions.

Use no-hardware test mode

> If this button is On when the telescope driver is started running then the driver is really started but it does not actually connect to the telescope. In this mode, the driver puts a marker on the Sky View at 0H RA 0 Dec. If you then place the cursor at some other location in the Sky View, right-click and release on Telescope GoTo, the marker will move to this new location. It is as though you are connected to a very fast telescope. This mode verifies that all the software is running correctly to operate the telescope and is a good troubleshooting step when first making your connections. Or for those who are easily entertained, it can also be fun to pretend you have a GoTo telescope.

Running

> This button turns the driver (named in the first line) on and off. When it is click On, it starts the driver, perhaps in no-hardware mode if that option is selected above.

Close

> This closes this window. Closing the window has no effect on telescope operation.

Help

> Shows this text.

Contact us at xephem@clearskyinstitute.com if you would like details on how to write a driver for a different telescope. If you have the details on your telescope command protocol, the driver will be easy to write.

10.7 History menu

This is the Sky View History control window. Most of the Sky View settings may be saved and restored as entries in the History list. This is handy for saving your favorite views for easy display.

The top pushbutton in the History pulldown menu brings up this window to Edit the list. Additional pushbuttons in the pulldown menu allow any one history entry to be applied immediately.

The control window shows the current set of History entries, one per line. Each line has the following format:

> **Apply** will engage the given entry, in the same way as choosing it from the pulldown menu.
>
> **Up** and **Down** allow the entries to be rearranged as desired. Remember to Save (see below) to keep the changes permanently for next time.
>
> **Delete** will remove the given entry.
>
> **Replace** acts as a combination Delete and Add (see below).
>
> The next section shows the basic display modes, the center coordinates and field of view.
>
> The field on the right allows you to enter a short descriptive label for the entry.

Buttons across the bottom allow for additional control of the History list:

> **Add** will capture the current Sky View settings and create a new History entry. A default label will be created but you should probably change it to something more descriptive if you plan to Save the list.
>
> **Save** will write all of the current History entries to a file. The file name is "xephem_skyhist" and will be created in the per-user directory.
>
> **Load** will read an existing file of History entries that has been previously Saved and make them the current set. First the per-user directory is searched then "auxil/" off the shared directory.
>
> **Close** closes the History window.
>
> **Help** displays this information.

10.8 Trails

The location of any object on the Sky view may be computed at regular intervals and displayed by setting up a sky trail. Use the Sky View Trails Setup dialog to select the interval, number of steps, formatting details and which steps you would like annotated (§15). The trail setup dialog is accessed from the popup which appears when the third mouse button is activated when the cursor is near an object. Any number of objects may have trails.

The trail is created by computing the location of the object at several intervals. Each new location will be drawn with a tick mark and connected with a line to its previous location. The trails remain correct if the display coordinate system is changed. Trails may be turned on or off without loss of trail information. Trail information is discarded if a trail is turned off when a new Main menu Update is performed. If any point on a trail is selected using the third mouse button the information displayed is as per the object at that time. The times displayed next to trailed objects are always in UTC. Trail information is not subject to the constraints in the Control->Filter dialog, i.e., trailed objects are always shown.

Note that in Alt-Az mode, if an object goes below the horizon the line segments and tick marks of the trail are displayed but they are not pickable and names are not drawn. Also, while each trailed location is accurately marked on the display, because of diurnal motion these trails are not useful for comparison with the background of fixed stars. Use the RA-Dec mode for that. This is so important (and easily overlooked) that you will see a reminder notice to this effect the first (and only) time you create and display a trail in Alt-Az mode.

Finally, be sure to recompute any trails if you change any of the preferences or circumstances in the Main menu.

10.9 Scale controls

FOV:

The vertical scale on the left side sets the vertical field of view of the display. The horizontal field of view is determined by the width of the window at the same scale. The FOV can be varied in 5 minute increments from 0:05 through 180 degrees. The buttons below present a quick way to set the scale to exactly 90 degrees and to resize the window (by changing the width) to 1:1 and 2:1 W:H aspect ratios.

Alt / Dec:

The vertical scale on the right side sets either the center altitude or declination, depending on the display mode. The value can be varied from -90 to +90 in increments of 5 minutes. The buttons below presents a quick way to center the scale at exactly 45, 0 or -45 degrees.

Az / RA:

The horizontal scale across the bottom sets either the center azimuth or RA, depending on the display mode. In Alt-Az mode this sets azimuth and can be varied from 0 to 359:55 degrees in steps of 5 minutes. In RA-Dec mode this sets Right Ascension and can be varied from 0 to 23:59:40 hours, in steps of 20 seconds.

11 Solar System view

Stereo pair

Perpendicular
leg down to
Ecliptic plane

Ecliptic
Plane

Parallax
control

Angle above or
below Ecliptic
Plane

Orbit

Sun

Zoom
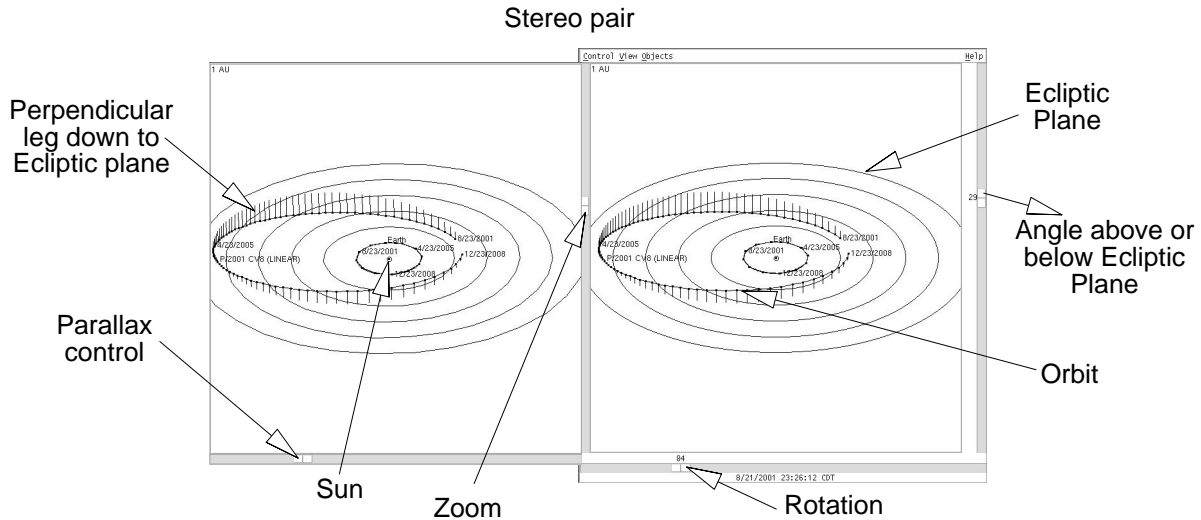
Rotation

This is a graphical representation of the solar system. The Sun is always at the center of the screen, marked with a small circle.

11.1 Mouse controls

Any object may be identified by pointing near it and clicking the right mouse button. This will bring down a temporary popup menu with additional information until the button is released. RA and Dec are displayed as of the time the dot was computed. The RA, Dec and Mag given for the Earth is that of the Sun.

Several controls may also be present on the popup menu, as follows.

Persistent Label:

This toggles whether the label for the object is displayed regardless of whether the View->Labels option is activated.

Assign ->
   To ObjX
   To ObjY
   To ObjZ

This cascade allows you to assign the given object to become ObjX, Y or Z, as desired (§13.3). This will also cause all other views which are currently making use of this object to be updated and the object will be added to and selected by the Data table.

Since this makes the object one of the User-Defined objects it will now appear directly in the Solar System->Objects pulldown menu.

Show in Data Table:

This option is only offered when the object chosen under the cursor is a planet, the Sun or the Earth. Selecting this option forces the object to be enabled in the Data Table(§3). Both the Sun and the Earth actually enable the Sun in the Data Table.

11.2 Control menu

Print...

    This selection allows printing the current Solar System view or saving it to a file.

Create Trails...

    This button will bring up a window to set up making a trail (§15) for each planet and user-defined object as they travel from their current positions. Each trail time is drawn connected together with a solid line with each point indicated with a small dot. The time stamps shown with the trails, if any, are always in UTC. For the trail to be visible, the Trails option must be activated.

    Only one set of trails is supported at a time. Creating new trails will delete the old ones. The trails will also be discarded if a user defined object is changed or an Update occurs from the Main window.

    Only the basic planets and user-defined objects, if defined, are trailed. The other solar system objects, if any, are always shown in their current positions.

    See the Help from the trail setup window itself for more details on how it operates.

Movie Demo:

    This push button will set the Main window Step to 5 days and start looping with a very large number of steps. Press the button again or use Stop control in the Main window to stop the movie.

Live Dragging:

    This toggle button selects whether the graphics are redrawn in real time as the various scale controls are being slid, or whether the graphics are not redrawn until the mouse is released. The decision depends on the speed of the computer, display and data bandwidth. If the system is fast enough, turning this on can produce dramatic depth queues for complex solar system views; also try it in Stereo.

Stereo pair:

    This toggle button is used to bring up another image of the solar system from a slightly displaced vantage point. Adjusting your gaze to fuse the two images together will reveal a 3D image. This effect is most pronounced if fairly lengthy trails are created and legs are enabled. This effect was designed primarily to help visualize the orbits of comets.

    At the bottom of the stereo display is a scale to control the amount of parallax to introduce. The parallax is only introduced in the plane of the ecliptic. This works well for low latitudes but has the odd effect of just moving everything as a whole when viewing from near the poles. If you prefer focusing your eyes in front of the screen, move the parallax control somewhat to the left; if you prefer to relax your eyes and focus at infinity then move the parallax control to the right.

Close:

>   This push button will close both the main Solar system view and the Stereo view. If the Solar System view is closed while the Stereo window is on, it will reappear when the Solar System window is reactivated.

11.3 View menu

Trails:

>   This toggles whether trails, if currently defined, are displayed for the basic planet objects and the three user-defined objects (if any). The trails may be turned on and off as desired without loss but the trails are permanently discarded at the next Update from the Main window.

Ecliptic:

>   This toggle button controls the display of a set of circles in the ecliptic plane, spaced at regular intervals. The interval between each circle is displayed at the upper left of the view.

Labels:

>   This option causes each object's name to appear.

Basic Legs:

>   This toggle button controls whether a line is drawn from each planet and any ObjXYZ user objects to the ecliptic. This aids in visualizing the 3D location of the objects.

DB Legs:

>   This toggle button controls whether a line is drawn from each Database object (other than planets and user ObjXYZ objects) to the ecliptic. This aids in visualizing the 3D location of the objects.

11.4 Objects menu

The planets and the user-defined objects ObjX, Y and Z, if they are solar system objects, may be individually turned on and off, without loss of any trail data associated with them, by using the toggle buttons in this "Objects" pulldown menu.

All Basic:

>   This pushbutton is a shortcut to turn on all the basic planets and user defined objects which are in the solar system.

Just S+E+ObjXYZ:

>   This pushbutton is a shortcut to turn on only the Sun, Earth and any user-defined objects which are solar system objects. It does not effect whether the other database objects at large are displayed.

>   For that, use the next control ...

All DB too:

>   This toggles whether /all/ solar system objects in the data base are also displayed. This is great when the asteroids database has been loaded.
>
>   In expectation of increased drawing time with all these objects, when this option is on the scales switch so they only cause an update when they are released at their new net position.
>
>   Note: these objects are never trailed. If you want to include one of these objects in a trail, first assign it to ObjX, Y or Z.

Note: Trail data is discarded at the time of the next Update from the Main window, regardless of whether the object is displayed at that time or not.

11.5 Scales

The three scales at the edges control the position of the observer. The vertical scale on the left controls the distance from the sun -- you are closer as the scale is slid further up. The horizontal scale under the view controls the heliocentric longitude -- think of it as a rotation about the central axis. The value of the scale is the heliocentric longitude towards you. The vertical scale on the right controls the heliocentric latitude -- your angle above the ecliptic plane.

Changes to the scales take effect as you drag, unless the View->All Objects option is on in which case the change does not take effect until you release the scale.

12 Tools

As interesting and entertaining as the visual displays are in *XEphem,* perhaps its greatest value is its quantitative features. The algorithms used for the planets are directly traceable to the JPL DE200 numerical integration and will match the *Astronomical Almanac* to full displayed precision. The natural satellites models were supplied by the French Bureau of Longitudes and are accurate to 0.5 arcsecond between the years 1996 and 2020 (2Q98) . Topocentric apparent place is computed by starting with astrometric mean place (including Solar deflection) and applying corrections for precession, nutation, aberration, relativistic deflection, parallax, and refraction (the latter two depend on accurate values for latitude, longitude, elevation and atmospheric pressure and temperature). Comet and asteroid ephemerides do not include perturbations but timely orbital elements are readily available for downloading via the Internet.

All of this accuracy can be tapped directly, as described in the next several sections. Many of these features take advantage of one common trait: all data fields throughout *XEphem* may be turned into Pushbuttons which allow them to be easily registered for use by these features. This eliminates the need to make manual notes or perform data copy-paste, and allows the data to be available programmatically at various date and time settings.

12.1 Plot values

This window controls the plot generation and display functionality of XEphem. You may select most numeric information displayed by XEphem, in pairs, to form x/y coordinates of a plot. You may select up to ten such pairs. You then select a file to contain the plot information. XEphem adds one line of information to the file for each x/y pair each time iteration step. XEphem can also plot any such file on the screen.

Selecting data to plot:

> Select the "Select fields" toggle button to make each field in the other menus that are eligible for plotting appear as a pushbutton. Select each such button as desired to form the x or y component of a plot. As you make the selections, they are listed in the menu. You may also associate a one-character tag with each line. These tags will be included in the plot display for identification later. Once all the field choices have been made you may return all the menus to their normal operational appearance by reselecting the same toggle button.

Specifying the plot file name:

> Type the name of the file to be used to contain the plot information in the text field provided. When XEphem first needs to write to the file, it will first check for the existence

of the file and, if it already exists, ask whether you wish to append to the file or overwrite it.

A leading '~/' in the filename will get expanded to the value of your HOME environment variable.

Specifying a plot file title:

Enter a short title for the plot information in the text are provided. When XEphem first writes to a plot file, it will place the contents of the title text area, if it is not empty, into the file as a comment. All lines within a plot file that do not begin with an alphanumeric character are considered comments and are ignored. If the first line of a file is a comment, XEphem will use it as the title for the plot when it displays the plot.

Generating the plot entries:

Once the fields have been specified and the plot file named and titled, you may select the "Plot to file" toggle button when ready. Now each time XEphem goes through one iteration the values you have selected and their tags will be written to the plot file. Note that when plotting is activated, XEphem does not update the screen until the "N Steps" count goes to 1. This greatly speeds the creation of plot files by avoiding screen updates. If you wish to watch each iteration, set "N Steps" to 1 and select the "Update" button manually for each iteration. Once all the desired data has been entered into the plot file, toggle the plot button back off to flush all data and close the file.

The windows that contain each of the fields used in the plot need not be visible while the plot is being generated.

Viewing plot files:

Existing plot files may be viewed by entering their name into the text field provided and selecting the "Show plot file" pushbutton. As many different plot files may be viewed simultaneously as desired. Each plot has separate controls for flipping the X and Y axes and for turning on and off a reference coordinate grid.
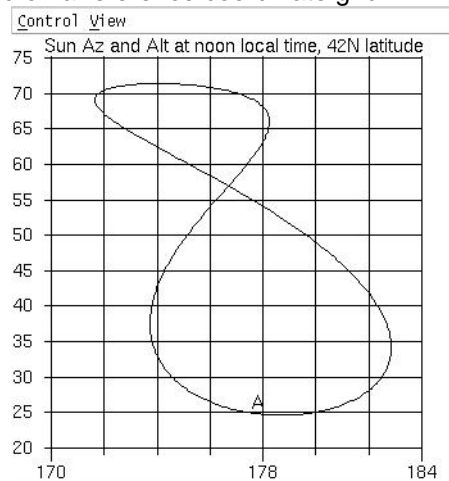
The XEphem distribution kit includes a sample plot file of the analemma.

12.2 List values

This window controls the list generation functionality of XEphem. The fields you select define columns of a table written to a file as XEphem runs. These columns look exactly like their corresponding fields on the XEphem windows and so are more familiar and readable than the entries in plot files. They are designed to be used in further text processing operations or printed as-is. Two spaces are placed between each column.

Selecting data to list:

Select the "Select fields" toggle button to make each field in the other windows that are eligible for listing appear as a pushbutton. Select each such button as desired to form each column of the listing. As you make the selections, they are listed in the table. Once all the column choices have been made you may return all the windows to their normal operational appearance by reselecting the same toggle button.

Specifying the listing file:

Type the name of the file to be used to contain the listing in the text field provided. When XEphem first needs to write to the file, it will first check for the existence of the file and, if it exists, ask whether you wish to append to the file or overwrite it.

A leading '~' in the filename will get expanded to the value of your HOME environment variable.

You may also elect to print the file in LaTeX table format by pressing the given button before beginning to list to the file.

Choosing to include column headings:

When this option is selected, column headings are written to the output file each time the file is opened.

Specifying a listing file title:

All lines within a listing file that do not begin with an alphanumeric character are considered comments and are ignored. When XEphem first writes to a listing file, it will place the contents of the title text area, if it is not empty, into the file as a comment for your convenience.

Generating the listing entries:

Once the fields have been specified and the listing file named and titled, if desired, select the "Create list file" toggle button. Now each time XEphem goes through one iteration the values you have selected will be written to the file. Note that when listing is activated, XEphem does not update the screen until the "N Steps" count goes to 1. This greatly speeds the creation of listing files by avoiding screen updates. If you wish to watch each iteration, set "N Steps" to 1 and select the "Update" button manually for each iteration. Once all the desired data have been entered into the listing file, toggle the list button back off to flush all data and close the file.

Menus that contain each of the fields used in the listing need not be visible for the fields to be listable.

12.3 Solve equation

This window controls the automatic equation solving facility. You define an arithmetic or boolean function, using most of the fields XEphem displays, then XEphem will automatically evaluate the function and adjust the time on each iteration to solve for the goal.

To set up a function to solve, follow these steps:

   Enter a function,
   Compile it,
   Select a goal,
   Set the desired accuracy,
   Enable solving,
   Start the solving process.

Each of these steps is described below.

Entering the function:

The function may be any arithmetic expression, in C-language syntax. All of C's comparison, logical and arithmetic operators are supported as well as several common arithmetic functions. Here is the complete list:

```
+ - * / && || > >= == != < <=
abs floor sin cos tan asin acos atan
degrad raddeg pi log log10 exp sqrt pow atan2
```

The function is entered into the text line provided. It may utilize most of the fields from the other XEphem windows. Press the "Enable field buttons" button to make each available field a button. Where ever a field is desired in the function, position the text insertion cursor at the desired position and select the field; its name will be inserted into the function text. When you are finished defining the function, turn off the field button appearance by selecting the "Enable..." button again. Once you get to know the names of the fields you may also enter them manually, if you prefer.

Compiling the function:

Once the function has been entered as desired, it must be compiled by selecting the "Compile" button (or by pressing the Return or Enter key on your keyboard). If there are any errors, a diagnostic message will appear just below the function. Once a function has been successfully compiled, the message will read No compile errors. If the function is modified, a message will remind you that it has not been compiled. Each time a function is successfully compiled, XEphem updates all fields and evaluates the function. As

explained below, this can be used as a sort of "astronomical calculator" even when not actually solving anything.

Selecting a goal:

You may choose from any of three evaluation algorithms, as selected by the trio of radio buttons. "Find extreme" will solve for a maxima or minima of the function. "Find 0" will solve for a time when the function evaluates to zero. "Binary" will keep incrementing time by "Step" (in the Main window) until the state of the function changes, then do a binary search to find the exact time when the function changes state. Binary search interprets a function that evaluates to zero to be in one state and all other values to be the opposite state. Generally, binary functions are comprised of logical operators at their outermost expression levels.

Specifying the desired accuracy:

Searching will automatically stop when the time changes by less than the the accuracy value. Note that this method of detecting convergence is not based on the value of the search function itself. To change the desired accuracy press the pushbutton showing the current accuracy next to the "Accuracy" label and enter a new value in the window.

Enabling the solver:

Once the function is defined and it compiles without errors, you may enable searching for a solution by selecting the button at the top labeled **Solving is Active**. Then, each time "Update" is selected on the Main window the solution advances by one time step until either "N Steps" iterations have occurred or until "Step" becomes less than Accuracy. The initial time and step size are set from the Main window, and are adjusted automatically as the solution proceeds. Note that by setting "N Steps" to 1 and repeatedly selecting Update you can effectively single-step the process. Solving will automatically turn off when convergence is detected, the function is edited or you may turn it off manually at any time by toggling the button labeled "Solving is Active" back off.

Additional notes on using the equation solver:

When selecting fields for plotting or listing a button appears labeled "Use for plotting". You may select this button to use the evaluated function as an item in the plot or listing feature. Note that the function may be used in plotting and listing whether or not actually solving is enabled.

The windows which contain the fields used in the function being solved need not be visible while solving is in progress.

The **Close** button removes the Solving window from the screen; it does not effect actual solver operation in any way.

A successfully compiled function is evaluated each time XEphem updates. Whenever the function is compiled it is also evaluated using freshly updated values. In this way, the Solve window can actually be used as an arbitrary "astronomical calculator" at any time, whether or not solving is actually active.

Hint:

Solving periodic functions can lead to solutions far from the intended range. You will get best results if you can start the search near the expected answer and with a small step

size that bounds the solution. You can use the plotting feature to study a function and get an idea of the solution, then use the solver feature to zero in.

12.4 Find close pairs

```
Control Options                                        Help
                    Max Sep (degs):    2.0
                    Mag limit:         20.0

              Found 3313 Topocentric Pairs <=  2:00:00
  13.88 171 Ophelia      15.55 857 Glasenapp     0:01:30
   5.34 Leo 53           17.32 1607 Mavis        0:02:17
   4.12 Vir Omicron-9    15.90 791 Ani           0:02:35
  13.80 NGC 4006         16.83 916 America       0:02:50
  15.50 NGC 3776         14.72 774 Armor         0:03:39
  14.50 NGC 5130         13.81 337 Devosa        0:03:40
  19.99 NGC 3345         15.74 1089 Tama         0:03:50
   5.82 Gem 52           11.62 128 Nemesis       0:03:58
   4.01 Sco Nu-14        14.49 167 Urda          0:05:21
   6.30 Sco Nu-14        14.49 167 Urda          0:05:58
  14.00 NGC 2720         15.33 226 Weringia      0:06:09
  15.37 635 Vundtia      16.50 1664 Felix        0:07:02
  14.00 NGC 3357         15.75 4820 Fay          0:07:31
  14.50 NGC 3580         14.17 212 Medea         0:07:38
   5.64 Lib Zeta1-32     15.14 858 El Djezai     0:08:03
  15.18 462 Eriphyla     16.62 1171 Rusthawe     0:08:04
  13.50 NGC 3032         13.66 328 Gudrun        0:08:24
  15.29 317 Roxane       15.12 358 Apollonia     0:08:24
  13.90 NGC 5705         19.77 3103 Eger         0:08:43
  14.00 NGC 2794         14.59 112 Iphigenia     0:09:00
  13.40 25 Phocaea       17.30 12008 1996 TY     0:09:21
              11/28/2000 19:25:07 UTC
```

This window allows you to scan the list of objects currently in memory for all pairs which are separated by less than a given angular distance.

First set up the desired maximum separation, in degrees, and faintest magnitude. Note that larger separations result in larger lists and hence longer sorting times. Also set other options via the Options menu. Separations will be topocentric or geocentric depending on the Equatorial preference in the Main menubar. Then start the scan via the Update button in the Control menu.

When the scan completes, all pairs meeting the criteria will appear in the scrolled list. The columns in the list are as follows:

```
    Magnitude_1 Name_1     Magnitude_2 Name_2      Separation
```

The entries are sorted in increasing order of separation. The total number of pairs and current conditions are reported above the list and the time when the scan was performed is indicated in the time stamp label below the list. The scan does not include field stars.

12.4.1 Control menu

Update

> This performs one scan. The XEphem cursor will change to the Watch shape until the scan is complete. The results are listed in the scrolled list when complete.

Sky Point

> This will place a cross-hair over the first object of the selected pair on the Sky View, re-aiming if it is currently not in the field. Either select the pair in the list then press this button, or double-click on the pair in the list. (These commands do nothing if the Sky View is not currently up.)

List to file...

This selection allows writing the current collection of close objects to a file.

A window is presented which allows you to enter a file name. If the file does not exist, the file is written as soon as you select Ok. If the file already exists, you are first asked whether you wish to append to the file or overwrite existing contents.

The format of the file begins with a header line that captures the conditions in effect when the set of close objects was built. Following the header, there is one line per pair with exactly the same information as appears in the window list.

Close

This closes the Close Objects window. The list is not modified in any way while it is closed.

12.4.2 Options menu

Auto update

When this option is active, a scan for close objects is performed automatically each time an Update is commanded from the Main window. The prior list is discarded each time. The list is never updated when the window is not open.

Auto list

When this option is active, the results of each scan are automatically appended to the file specified in the "List to file" window. This works whether the scan was performed explicitly via the Control -> Update command here or implicitly via an Update from the Main window and the "Auto update" option is active.

Omit fixed pairs

When this option is active, then pairs of Fixed objects are not listed.

12.5 Night at a Glance
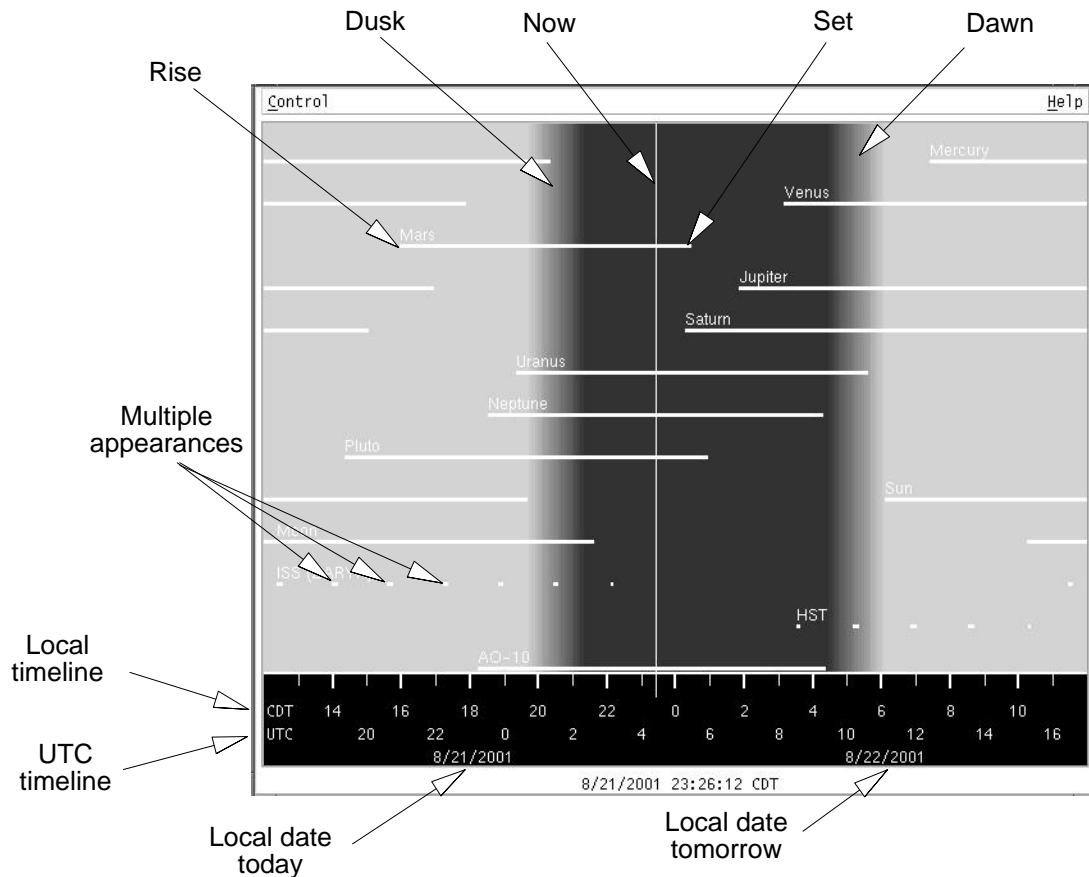
This window displays the current day, with local midnight in the center. Across the bottom is a scale marking local dates and time and UTC time, at each even hour. The current *XEphem* time is marked with a thin vertical line.

The background gray shading shows when the Sun is up, down and periods of twilight. The twilight period matches the Sun Dip setting in the main XEphem window.

Overlayed on the gray background is one thick horizontal line for each basic object and any of the user objects ObjX,Y,Z that are defined. The lines show when the object is above the horizon, as defined in the Data View->Control->Setup horizon parameter.

Clicking with the right mouse button near an object's line will pop up its rise, transit and set information. This is with respect to the day in which the moment occurs corresponding to the mouse click location. A button is also included in the popup to set the main XEphem time to this moment. If the mouse is clicked far from any object, then just the time is presented.

The lines and text colors are set based on type of object, or can all be set to one color using the Control->One color toggle.

The window may be printed using the Control->Print menu option (§14).

An interesting exercise is to set up a time loop with a Step size of a few days and watch how the rise and set times of objects and the amount and timing of night time are effected throughout the year.

12.6 AAVSO light curves

AAVSO designation

GCVS name

Start date

End date

Data from AAVSO

GCVS stars near last Sky View cick

```
                    Courtesy http://www.aavso.org
Name and date range:                    Near last Sky View pick:
     Designation:  2030+46             2043+45   CY CYG
            Name:  TV CYG              2040+44   NSV 13262
   Start JD or Date  default           2042+44A  RR CYG
                                       2042+44B  BZ CYG
    End JD or Date   latest            2045+45   V1661 CYG
                                       2030+46   TV CYG
```

```
        WWW.AAVSO.ORG UNEVALUATED DATA FOR TV CYG 2030+46
    5                                    Observation  ◆
                                         Fainter than △
    6

    7

    8
Mag
    9

   10

   11

   12
    51100   51200   51300   51400   51500   51600   51700   51800
                     Julian Date 2,400,000+
```

| Get Curve | Print | Close | Help |

This window provides easy access to the database of variable star light curves maintained by the American Association of Variable Star Observers, AAVSO. Many thanks to AAVSO for their support of *XEphem*.

First make sure your Internet connection is functioning. The connection may be made directly, or via a Proxy or SOCKS server. These may be configured in the File->Network setup window (§2.1.1).

To display a light curve:

1. Enter the AAVSO Name or Designation in the fields in the upper left. For example, OMI CET for Mira. If both are entered, the Designation has priority.

2. Enter a range of dates for the data to be retrieved. These may be given as a Julian Date or in the current Date format as set in the Main Preference menu. The Starting date may also be given as "default" which is about 2 years of data; the Ending date may also be given as "latest" which means the newest data available from AAVSO.

3. Press Enter or the **Get Curve** button at the bottom.

To print the current light curve, press **Print**.

The Sky View may also be used to specify an object as follows:

1. Position the cursor near the desired sky location in the Sky View.

2. Press and hold down the right mouse button.

3. Slide down the popup menu to AAVSO and release.

4. The 5 stars in the AAVSO that are nearest to the cursor position are shown in the list in the upper right sorted by ascending order of distance.

5. Click on one entry in the list to move it to the Name and Designation fields on the left and proceed as above to display a light curve. Or if the date ranges are already set as desired, double-click the entry in the list and the curve will be fetched immediately.

The database AAVSO.edb is specially tailored to match the official names of stars maintained in the databases at AAVSO. Using this database will facilitate the selection and retrieval of AAVSO light curves. Databases can be changed from the Data -> Load/Delete menu in the Main window.

12.7 SETI@home

```
SETI@home client directory:

~/setiathome/setiathome-3.0

        Refresh                 ☐ Auto refresh

        Sky Point                    Sky Mark

 Refreshed: Wed Nov 29 01:38:50 2000 GMT

 User name: Elwood C. Downey
 User email: ecdowney@clearskyinstitute.com
 Registered: Tue Aug 31 23:49:31 1999 GMT
  Total CPU: 279 days + 13:45:25
 Work units: 322 sent
  Last Sent: Tue Nov 28 04:50:32 2000 GMT

 Work unit: 04oc00ab.5081.4144.840898.16
   Recorded: Thu Oct  5 00:52:24 2000 GMT
   Position: RA=20:56:42 Dec= 10:01:12
   Receiver: ao1420
  Frequency: 1.42015625000 GHz
    Doppler: 8.59746 Hz/sec
   CPU time:  9:01:42
   Progress: 32.43%
  Remaining: 18:48:42

        Close                        Help
```

This window can read and interpret the various log files which accompany the SETI@home client, version 2 and 3. For full details about this remarkable project, see
`http://setiathome.ssl.berkeley.edu`.

Enter into the text field at the top the path to the directory in which the setiathome client is running.

The controls operate as follows:

Refresh

Reread the log files in the SETI@home directory specified about and produce a new report. An error is reported if any of the required files can not be read.

Sky Point:

This will center the Sky View at the position of the work unit currently being processed. It also assigns the location of the work unit to user-definable object OBJZ; doing so will add it to the Locate pulldown menu of the Sky View and add it to the View->Data table for easy reference.

Sky Mark:

This will mark the position of the work unit currently being processed on the Sky View, but only if it is already within the Sky View field of view. The Sky View is never re-aimed with this command. This always also assigns the location of the work unit to user-definable object Obj Z (§13.3); doing so will add it to the Locate pulldown menu of the Sky View and add it to the View->Data table for easy reference (§3).

Auto refresh

When this toggle is active, a **Refresh** is performed automatically every 10 seconds. This toggle is turned off when the window is closed.

The large text box contains some report details. Most entries are taken directly from the setiathome status files. The Refreshed: entry is the time and date at which the display info was produced; its time zone is as per Preferences->Time zone (2.5).

At the bottom are controls to **Close** the window and see this **Help** information.

12.8 Coordinate Converter

```
Altitude: [  50:16:20.5 ]    Azimuth: [ 207:09:36.1 ]
RA @ 2000.0: [   0:1 :15.8 ]  Declination: [   5:08:13.6 ]
Galactic lat: [ -55:31:49.5 ] Galactic lng: [ 100:27:43.7 ]
Ecliptic lat: [   4:35:12.0 ] Ecliptic lng: [   2:20:14.7 ]

           10/16/2001  0:20:53 CDT
  [ Close ]  [ Sky point ]  [ Get sky ]  [ Canonize ]  [ Help ]
```

This window performs simple conversions among several common astronomical coordinate systems. Simply type (or paste) into any text field and the others will update immediately.

All fields are in units of Degrees except RA is in Hours. Fields may be entered in either sexagesimal or decimal format. For example, either 10:30:00 or 10.5.

Altitude and Azimuth are with respect to the time and location set in the Main window. These will change to correspond to the RA and Dec values if an Update is performed.

The Equinox for the RA and Dec values is the one shown in the Main window.

The controls across the bottom perform as follows:

Close

Closes this window.

Sky point

Marks the coordinates shown on the Sky View map, recentering if necessary to place it in the field of view.

Get sky

Loads each field from the current center position of the Sky View.

Canonize

Reformats each field in a consistent manner for easier viewing.

Help

Display this text.

13 Data

XEphem works with objects in memory. The controls in this section provide facilities to manage this set.

13.1 Load and Delete
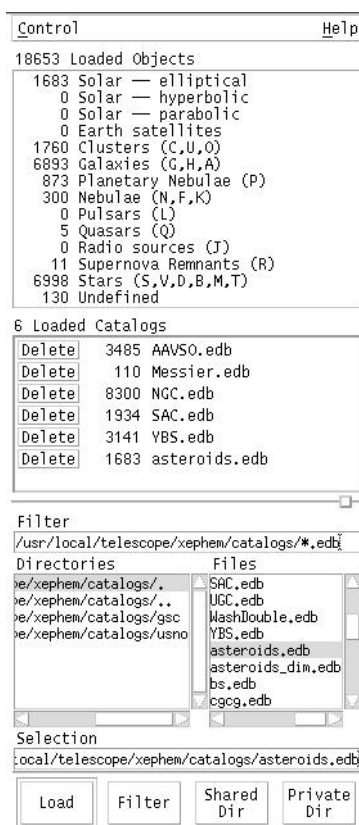
This window allows you to load, delete and inspect the collection of objects that are currently in memory. These objects form what is referred to as the XEphem database.

The top section of the window displays a count of each major type of object and the total number in the database. The counts do not include the planets, Sun, Moon or the user-defined objects ObjX, Y and Z.

The center section lists the catalogs which are currently loaded and the number of objects they contributed. The objects loaded from a catalog may be deleted using the button to the left of the count. This list may be saved at any time so this set of catalogs is automated loaded when XEphem starts. To do so, go to Preferences->Save and Save the XEphem.DBInitialFiles resource under the Data Base category.

The lower section allows you to browse the directory structure on your system for database files in XEphem format and load them into memory. See the README in the base distribution for a brief description of each catalog. The Filter field sets the directory and file name pattern to qualify being included in the list of Files. Any directory may be searched but handy buttons at the bottom right allow setting the directory to the values of the **Shared** and **Private** directories. The **Filter**

button in the lower center forces the directory given in the Filter field to be rescanned for all files which match the filter pattern therein. Double-click on a directory to show the files which match the pattern.

A database file is loaded into memory by selecting the file name in the list at right then pressing **Load** at the bottom of the window, or by double-clicking its name in the list. Both .edb and .tle formatted files are supported. If the file is already loaded, it will first be deleted. If the file contains exactly one entry, the object may also be automatically assigned to a user-defined object; see Help->on Control for more details.

Or rather than browsing, any file name may be simply explicitly typed in the Selection field and loaded by typing Enter or pressing Load.

The sash in the center of the window controls the proportion of space allocated to the Catalogs and Browse sections as desired.

XEphem may also load objects from another process via a fifo. Please refer to the separate description of this facility in Help->on Control, §13.1.1 .

13.1.1 Control menu

Delete all

Deletes all file and their objects from memory. The files on disk are not effected.

Open DB Fifo

Listen for database objects arriving via a fifo from another process. XEphem attempts to reopen the fifo each time the button is pressed.

The file name of this fifo is `fifos/xephem_db_fifo` off the shared directory.

All relevant displays are automatically updated when data arrives via this fifo. The format of the fifo data is exactly the same as for any XEphem database file. Due to the way the fifo data is read and processed, it is important that each line be terminated with a newline; incomplete last lines can result in loss of information.

No Dups

If this toggle is on then when a new database file is loaded, objects from other catalogs whose name already exists in memory will be silently skipped. This option does /not/ check for duplicates among the user defined objects, ObjX/Y/Z, nor entries within the new file itself.

Load Obj when 1

If this toggle is on then when a new database file is loaded and it defines exactly one object, it will also be assigned to one of the user defined objects, ObjX, Y or Z. The one affected is the first which is either undefined, whose name matches the new object, or ObjZ. This feature is also available for files loaded when XEphem first starts.

Close

Closes the Data Base window.

13.1.2 .edb File format

Follows is the description of the format of an XEphem database file. The file name extension is .edb.

General Information:

Each object occupies one line in the file. Lines are separated into Fields using commas (,). Some fields are further subdivided into Subfields with vertical bars (|). Lines beginning with anything other than a-z, A-Z or 0-9 are ignored and may be used for comments. The order of objects in a file does not matter.

Where they appear, all date fields may be in either of two forms:

1) month/day/year, where day may contain a fractional portion. examples: 1/1/1993 and 1/1.234/1993

NOTE: the format of dates in database files is always M/D/Y, regardless of the current XEphem Date format Preference setting.

2) year as a real-number, such as 1993.123.

Field Definitions:

The first two fields are always Name and Type. Remaining fields depend on Type.

The Name field is the object's name. Any number of characters may be present but only the first 13 are retained as significant.

The Type field consists of a single letter designating the form of the object's motion and must be one from the following set:

f: fixed (no proper motion) e: heliocentric elliptical orbit h: heliocentric hyperbolic orbit p: heliocentric parabolic orbit E: geocentric elliptical orbit, i.e., Earth satellite

If Type is "f" (**fixed**), an object class code may follow in the next subfield:

A: Cluster of galaxies
B: Star, binary
C: Cluster, globular
D: Star, double
F: Nebula, diffuse
G: Galaxy, spiral
H: Galaxy, spherical
J: Radio
K: Nebula, dark
L: Pulsar
M: Star, multiple
N: Nebula, bright
O: Cluster, open
P: Nebula, planetary
Q: Quasar
R: Supernova remnant
S: Star
T: Stellar object

U: Cluster, with nebulosity
V: Star, variable

if class is one of T, B, D, S or V, the spectral class and possibly the numerical subclass designation may follow as 1 or 2 characters in the next subfield.

if class is G or H, the size field (described next) may include minor axis and position angle as subfields.

The remaining fields for Type f are as follows:

RA, hours
Declination, degrees
magnitude
reference epoch, optional, assumed to be 2000 if absent
size = angular size, arc seconds, optional.

For elliptical objects such as galaxies, this field may be divided into 3 subfields if desired: the size of the major axis, the size of the minor axis (both in arc seconds), and the position angle, in degrees E of N.

These 3 subfields can also apply to double stars, where the first subfield is the separation in arc seconds, the second subfield is set to 0, and the third field is the position angle.

If the Type is "e" (**elliptical heliocentric**, eccentricity < 1) the remaining fields are defined as follows:

i = inclination, degrees
O = longitude of ascending node, degrees
o = argument of perihelion, degrees
a = mean distance (aka semi-major axis), AU
n = mean daily motion, degrees per day (computed from a**3/2 if omitted)
e = eccentricity,
M = mean anomaly (i.e., degrees from perihelion),
E = epoch date (i.e., time of M),
D = the equinox year (i.e., time of i/O/o).
g,k or H,G = two fields which define the magnitude model; select which by preceding the
        first field with a "g" or an "H" (2 parameters)

If the Type is "h" (**hyperbolic heliocentric**, eccentricity > 1) the remaining fields are defined as follows:

T = epoch of perihelion
i = inclination, degrees
O = longitude of ascending node, degrees
o = argument of perihelion, degrees
e = eccentricity,
q = perihelion distance, AU
D = the equinox year (i.e., time of i/O/o).
g,k = two fields which specify the magnitude model
s = angular size at 1 AU, arc seconds, optional

If the Type is "p" (**parabolic heliocentric**, eccentricity == 1) the remaining fields are defined as follows:

> T = epoch of perihelion
> i = inclination, degrees
> o = argument of perihelion, degrees
> q = perihelion distance, AU
> O = longitude of ascending node, degrees
> D = the equinox year (i.e., time of i/O/o).
> g,k = magnitude two fields which specify the model
> s = angular size at 1 AU, arc seconds, optional

If the Type is "E" (**Earth satellite**) the remaining fields are defined as follows:

> Epoch
> inclination, degrees
> RA of ascending node, degrees
> eccentricity, must be < 1
> argument of perigee, degrees
> mean anomaly, degrees
> mean motion, revolutions/day
> orbit decay rate, revolutions/day^2
> integral reference orbit number at Epoch
> drag coefficient, 1/(earth radii); optional
>
> The venerable Two-Line-Element (TLE) format is also automatically detected and supported. For a complete discussion of TLE format see `http://www.celestrak.com`.

13.1.3 Notes

XEphem does not use the facility controlled by this window for so-called Field Star catalogs. See the Help for Data->Field Stars for more information on managing these special catalogs.

XEphem ships with a few perl scripts which might be helpful for converting databases in other formats into XEphem format. These scripts are in the tools/ directory of the XEphem source distribution tree.

13.2 Download Internet files

```
Download a file containing .edb or TLE formats:
  Get |http://celestrak.com/NORAD/elements/stations.txt         |
  Get |http://celestrak.com/NORAD/elements/science.txt          |
  Get |http://celestrak.com/NORAD/elements/amateur.txt          |
  Get |http://cfa-www.harvard.edu/iau/Ephemerides/Comets/Soft03Cmt.txt      |
  Get |http://cfa-www.harvard.edu/iau/Ephemerides/CritList/Soft03CritList.txt|
  Get |http://cfa-www.harvard.edu/iau/Ephemerides/Distant/Soft03Distant.txt |
  Get |http://cfa-www.harvard.edu/iau/Ephemerides/Unusual/Soft03Unusual.txt |
  Get |                                                          |
      □Search during download for |ao-10|
 .edb or TLE spec:    Erase     Assign to: ObjX  ObjY  ObjZ
 AO-10
 1 14129U 83058B   01283.16929832  .00000147  00000-0  10000-3 0  8428
 2 14129  26.2869 248.8225 6028608 189.6254 149.3718  2.05867567109849
 Download large daily epoch asteroid data set:
   Get  from Minor Planet Center, saved in AstMPC.edb and AstMPC_dim.edb
   Get  from Lowell Observatory, saved in AstLowell.edb and AstLowell_dim.edb

        Close                        Help
```

This window provides an easy means to download any file which contains objects defined in either XEphem's .edb format or the NORAD 2-Line Element (TLE) format commonly used for Earth satellite. While downloading a file, any set of lines found to match either format are extracted and saved to a file named the same as the last component of the URL except for changing the

extension to .edb if necessary. In this way, XEphem automatically detects either format and derives a sensible file name.

Several particularly useful sites as of this build are already entered. The first three are Dr. TS Kelso's Earth satellite lists. The other four are the Minor Planet Center's lists of hot comets and unusual asteroids.

During the download, a search pattern may be entered to look for an object with a name containing the pattern. Click on the Search option and enter the desired pattern. The comparison ignores case and blanks. If a match is found, the entry is shown in the text block. If more than one match, the first is shown. Regardless of whether any match the entire file is saved.

Whenever a valid object specification in either format is in the test box, it may be assigned to User Defined Object X, Y or Z by clicking the appropriate button. The specification may be entered by hand or copy/paste; it need not have come from a downloaded file.

Special Asteroid files:

Special files created by the Minor Planet Center and Lowell Observatory may also be downloaded. Each organization maintains extensive lists of all known asteroids and produces on a regular basis Keplarian orbital elements precessed to the current date. Both are of excellent quality, but Lowell's list is some 20% longer.

When the "Get" button is clicked, XEphem downloads the appropriate file, uncompresses it, reformats it to .edb format and splits the results into two files for convenience. One file will contain all asteroids which can ever become brighter than magnitude 13, and the other (with a "_dim" suffix) contains all the rest. The search pattern facility does not apply to these files.

All files are created in the user's Private XEphem directory.

Special thanks to these organizations for their service.

13.3 Search, Obj X, Y, Z

This window allows you to select, inspect and modify any object currently in memory. It also allows you to control the user defined objects, ObjX, ObjY and ObjZ.

XEphem supports three user-defined objects, denoted ObjX, Y and Z. These may be fixed objects; objects in elliptical, hyperbolic or parabolic heliocentric orbits; or objects in geocentric elliptical orbits. The ObjX/Y window allows you to define these objects.

XEphem maintains a working copy of these objects for use with the ObjX/Y/Z window that is separate from the real ObjX and ObjY and ObjZ. The ObjX/Y/Z window always works on these working copies. The working copies and the real ObjX/Y/Z only interact when using the Ok, Apply and Reset control, as described shortly.

This window is always displaying information from one of these working copies as indicated by the small radio box in the top center of the window. The radio box may also be used to change whether ObjX, Y or Z is being displayed and manipulated. We will refer to the one selected as the "current working object."

The radio box in the upper left displays the basic type of the current working object. This can be changed by selecting another of the collection of toggle buttons.

In the left and center of the window is an area that lists each field for the current working object and its present value. The list is adjusted to correspond to the fields that are associated with the type of the current working object. These fields may be changed by selecting the button that contains their value. This will bring up a small text entry window. A new entry may be typed into the window box and applied by typing Enter or selecting the **Ok** button. The value may be left unchanged by selecting **Cancel**.

Along the right edge of the window is a list of each object currently loaded into the XEphem database. (See the Help for the "Database Load and Delete" window for more information on manipulating this data base, §13.1).) If there are more than 20 items then a scroll bar may be used to browse through the list. The entries are sorted in numeric and alphabetic order, ignoring case, for easy browsing. If one of these objects is picked, then it is copied to the current working object. You may then edit the values for this working object, if desired, without effecting the original.

Below the list of names is a text field with which you may select an object by name. Enter a string and type Enter or press the Search: pushbutton. All objects in memory will be searched for one with a name that contains the string. Whitespace and case are ignored. To anchor the string to be at the beginning of the object's name precede the string with a caret (^). If a match is found, the list is scrolled so the object is at the top and the object is copied to the current working object. To select again with the same string, type Enter or press the Search: pushbutton again. XEphem beeps if no matches are found.

When the current working object is as you want it, select **Apply** to copy it into the real ObjX (or ObjY or Z) used throughout the other functions of XEphem. **Ok** will do the same thing and also close the window.

Other controls include:

Reset

   load the current working object with a copy of the real ObjX (or ObjY or Z).

Sky Point

   mark the current working object on the Sky View with a cross-hair, re-aiming if it is not currently in the field. The object is marked even if the object does not match the Sky View filter or is outside the magnitude range. The only time the object will /not/ be marked is if the display mode is set to Alt-Az mode and the current working object is below the horizon.

Sky Mark

   will draw a cross-hair on the Sky View window at the location of the current working object but only if it is already within the Sky View field of view. The Sky View window is never re-aimed with this command.

Set Tel

will cause the coordinates of the current object to be sent to the xephem_loc_fifo fifo, which is typically connected to a telescope control process. The command is not issued if the object is currently below the horizon. See the discussion at Sky_View->Help->on Telescope for more information (§10.6).

13.3.1 Fixed objects

Fixed objects are characterized by five parameters:

RA,
Dec,
magnitude,
the reference epoch for the coordinates and
angular size in arc seconds, optional

Note:

In order to conserve memory usage, XEphem stores the astrometric RA and Dec for a fixed object only once with each object. These values are always precessed *in place* to the current display equinox. Thus, you will find that the RA and Dec displayed for a given object may change if the equinox is changed on the main menu and the object information is redisplayed here on the ObjX/Y menu.

13.3.2 Elliptical objects

Elliptical objects are characterized by 12 parameters: the parameters that define a heliocentric elliptic orbit and the coefficients for either of two magnitude models. These elements are the same ones often listed in the Astronomical Almanac. The elements are, in order:

i = inclination, degrees
O = longitude of ascending node, degrees
o = argument of perihelion, degrees
a = mean distance (aka semi-major axis), AU
n = mean daily motion, degrees per day
e = eccentricity
M = mean anomaly (i.e., degrees from perihelion)
E = epoch date (i.e., time of M)
D = the equinox year (i.e., time of i/O/o)
g,k or H,G = two fields to specify either of two magnitude models; see
    below
s = angular size at 1 AU, arc seconds, optional

You might have other parameters available that can be converted into these. The following relationships might be useful:

    P = sqrt(a*a*a)
    p = O + o
    n = 0.9856076686/P
    T = E - M/n
    q = a*(1-e)
    AU = 149,597,870 km = 92,955,621 U.S. statute miles
 where
    P = the orbital period, years;
    p = longitude of perihelion, degrees
    T = epoch of perihelion (add multiples of P for desired range)
    q = perihelion distance, AU

Note that if you know T you can then set E = T and M = 0.

XEphem supports two different magnitude models for elliptical objects. One, denoted here as g,k, is generally used for comets in elliptical objects. The other, denoted H/G, is generally used for asteroids in the Astronomical Almanac.

The g,k magnitude model requires two parameters to be specified. One, the absolute magnitude, g, is the visual magnitude of the object if it were one AU from both the sun and the earth. The other, the luminosity index, k, characterizes the brightness change of the object as a function of its distance from the sun. This is generally zero, or very small, for inactive objects like asteroids. The model may be expressed as:

    m = g + 5*log10(D) + 2.5*k*log10(r)
 where:
    m = resulting visual magnitude;
    g = absolute visual magnitude;
    D = comet-earth distance, in AU;
    k = luminosity index; and
    r = comet-sun distance.

Note that this model does *not* take into account the phase angle of sunlight.

When using this model for elliptical objects, the first of the two magnitude fields must be preceded by a letter "g". This applies in both the .edb database file and the corresponding menu elliptical object definition prompt; otherwise the default magnitude model for elliptical objects is the H/G model.

The H/G model also requires two parameters. The first, H, is the magnitude of the object when one AU from the sun and the earth. The other, G, attempts to model the reflection characteristics of a passive surface, such as an asteroid. The model may be expressed with the following code fragment:

    beta = acos((rp*rp + rho*rho - rsn*rsn)/ (2*rp*rho));
    psi_t = exp(log(tan(beta/2.0))*0.63);
    Psi_1 = exp(-3.33*psi_t);
    psi_t = exp(log(tan(beta/2.0))*1.22);
    Psi_2 = exp(-1.87*psi_t);
    m = H + 5.0*log10(rp*rho) - 2.5*log10((1-G)*Psi_1 + G*Psi_2);
 where:
    m   = resulting visual magnitude
    rp = distance from sun to object

rho = distance from earth to object
rsn = distance from sun to earth

Note that this model does *not* take into account the phase angle of sunlight.

The H/G model is the default magnitude model for elliptical objects but it can also be explicitly indicated when the first of the two magnitude fields is preceded by a letter "H". This works in both the .edb database file and the corresponding menu elliptical object definition prompt.

13.3.3 Hyperbolic objects

Hyperbolic objects are characterized by 10 parameters: the parameters that define a heliocentric hyperbolic orbit and the magnitude model coefficients. These orbital parameters are, in order:

T = epoch of perihelion
i = inclination, degrees
O = longitude of ascending node, degrees
o = argument of perihelion, degrees
e = eccentricity,
q = perihelion distance, AU
D = the equinox year (i.e., time of i/O/o).
g,k = two fields for the magnitude model
s = angular size at 1 AU, arc seconds, optional

As with elliptical elements, other parameters might be available. The relationships are generally the same, except for:

q = a*(e-1)

The g,k magnitude model requires two parameters to be specified. One, the absolute magnitude, g, is the visual magnitude of the object if it were one AU from both the sun and the earth. The other, the luminosity index, k, characterizes the brightness change of the object as a function of its distance from the sun. This is generally zero, or very small, for inactive objects like asteroids. The model may be expressed as:

m = g + 5*log10(D) + 2.5*k*log10(r)
 where:
  m = resulting visual magnitude;
  g = absolute visual magnitude;
  D = comet-earth distance, in AU;
  k = luminosity index; and
  r = comet-sun distance.

Note that this model does *not* take into account the phase angle of sunlight.

13.3.4 Parabolic objects

Parabolic objects are characterized by 9 parameters: the parameters that define a heliocentric parabolic orbit and the magnitude model coefficients. These orbital parameters are, in order:

T = epoch of perihelion
i = inclination, degrees
o = argument of perihelion, degrees
q = perihelion distance, AU
O = longitude of ascending node, degrees
D = the equinox year (i.e., time of i/O/o).

g,k = two fields for the magnitude model
s = angular size at 1 AU, arc seconds, optional

The g,k magnitude model requires two parameters to be specified. One, the absolute magnitude, g, is the visual magnitude of the object if it were one AU from both the sun and the earth. The other, the luminosity index, k, characterizes the brightness change of the object as a function of its distance from the sun. This is generally zero, or very small, for inactive objects like asteroids. The model may be expressed as:

$$m = g + 5*log10(D) + 2.5*k*log10(r)$$
where:
m = resulting visual magnitude;
g = absolute visual magnitude;
D = comet-earth distance, in AU;
k = luminosity index; and
r = comet-sun distance.

Note that this model does *not* take into account the phase angle of sunlight.

13.3.5 Earth satellites

Objects in Earth orbit are characterized by 9 parameters: the parameters that define a geocentric elliptical orbit. These orbital parameters are, in order:

Epoch of the measured values
inclination, degrees
RA of ascending node, degrees
eccentricity, must be < 1
argument of perigee, degrees
mean anomaly, degrees
mean motion, revolutions/day
orbit decay rate, revolutions/day^2
integral reference orbit number at Epoch

XEphem treats all earth satellites as if they had a visual magnitude of 2.0.

13.4 Field Stars

This window allows you to control which field star sources you wish to use. The window is accessible from the Main window as well as from the Control menus of most graphical views.

XEphem uses the term "field star" to refer to the huge numbers of faint stars visible in any real world view of the sky. Field stars are generally far more numerous than could be reasonably accommodated in the XEphem *.edb database format. For this reason they are stored and made available in their own special compact forms for utmost efficiency. The downside to this approach is that field stars are not included in the totals presented by the Data->Load window nor are they available for searching or inspection using the Data->Search window. This results in little loss of generality, however, since (once found!) they may be assigned to the user defined objects (ObjX, Y or Z) by using the popup menu in the Sky view and thus be further investigated via the Data table window (§3).

The controls in the Field Stars setup window are grouped into categories, depending on the basic source of the stars.

Hubble Guide Star Catalog:

This is the seminal work created by the Space Telescope Science Institute to support the Hubble Space telescope. It contains from 13 million unique stars, or about 300 stars per square degree of sky. It may be accessed with XEphem in the following ways:

ASP CDROM Directory:

This choice enables reading field stars from the Hubble Guide Star Catalog available on two CDROMs published by the Astronomical Society of the Pacific.

Mount a CDROM somewhere onto your filesystem, type the name of the mount directory in the text field provided then turn this option on and press Apply. Note that XEphem assumes your CDROM driver removes the trailing ";1" from all filenames.

Local Cache Directory:

This choice enables reading GSC field stars from your local disk. If this option is on along with the CDROM option, then as requests are satisfied from the CDROM a compact form of the same data will be written to files below the directory named in this option. Then the next time the same field stars are needed, and this option is on, they will be obtained from the local disk files rather than the CDROM. In fact, the CDROM is not needed or used if the local disk contains all the stars for any given access. The entire 2 CDROM set loads onto disk in this format in some 180 MB.

The default path of the directory which holds the disk version is "catalogs/gsc" off the shared directory.

Note: There is also a utility in the tools/gsc directory, gscload, with which you may preload an entire ASP CDROM segment at once if desired.

(These files are already included in the commercial version of XEphem.)

Internet to xephemdbd:

This choice is to use the Internet to access an XEphem GSC server. See the XEphem home page for the current list of GSC server hosts.

To use this source, select this option and type the URL to the remote xephemdbd.pl in the text field provided.

Internet to ESO:

This choice accesses the GSC catalog service maintained by the European Southern Observatory. This choice emulates a web browser query and uses the Proxy or SOCKS facilities (described below) which should make it accessible to user behind firewalls.

The CDROM or the cache options may not be used at the same time as the network options.

Note that the ESO GSC server (apparently) arbitrarily and (certainly) silently restricts the total number of stars it will return, so larger and/or deeper fields may not contain all stars.

You may also access this service directly from your Web browser at `http://archive.eso.org/cgi-bin/gsc.`

USNO A or SA catalogs:

This choice of field stars supports the SA or even the A series of astrometric catalogs produced in recent years by the US Naval Observatory. The SA2.0 for example, includes some 54 million stars, spatially sampled so there is about 1,300 stars per square degree of sky. Note that such a uniform distribution does not "look" much like the real sky, but it is great for its intended use as an astrometric mesh for comet hunters or such.

Root directory:

To order these catalogs, see `http://psyche.usno.navy.mil/pmm.`

If you have such a catalog, simply enter the name of its base directory and toggle this switch on. The default assumes a symbolic link, "catalogs/usno" off the shared directory.

The suggested citation for SA1.0 follows:

Monet, D., Bird, A., Canzian, B., Harris, H., Reid, N., Rhodes, A., Sell, S., Ables, H., Dahn, C., Guetter, H., Henden, A., Leggett, S., Levison, H., Luginbuhl, C., Martini, J., Monet, A., Pier, J., Riepe, B., Stone, R., Vrba, F., Walker, R. 1996, USNO-SA1.0, (U.S. Naval Observatory, Washington DC).

This catalog has been included with permission of USNO as long as we mention the follow stipulations

It may not be the latest version, check with http://ad.usno.navy.mil.

If you paid for XEphem, you paid for the software, not this catalog. The catalog is available free from the USNO.

Inclusion of the SA2.0 catalog does not imply an endorsement of XEphem by USNO; nor did I have privileged access to the catalog; nor does the US Government affirm or guarantee that XEphem works properly in any way.

Proper Motion catalogs:

These catalogs include information regarding proper motion. The position of the star is moved to its location according to the current XEphem time *when the stars are loaded*. In order to see a movement, change the time, and watch carefully.

Two such catalogs are currently available ready for XEphem. You may only use one at a time, by choosing the corresponding toggle.

PPM catalog:

This is the Positions and Proper Motion catalog of S. Roeser and U. Bastian, Astronomisches Rechen-Institut, Heidelberg, published in 1990. The PPM includes 468,586 stars rather evenly distributed throughout both hemispheres. This averages out to more than 10 stars per square degree. The set includes the original North and South editions plus the extended supplement. The set includes more than 99% of the stars in the original SAO catalog and some 70% of the Henry Draper Catalogue (HD).   While the SAO catalog is more or less complete to V=9, with stars as faint as V=10, the PPM catalog is fairly complete to V=9.5, and goes somewhat deeper than V=10.

Hipparcos and Tycho-2:

This catalog is a combination of the Hipparcos and the Tycho-2 astrometric catalogs published by the European Space Agency. These are now considered the best proper motion catalog in available.

This catalog contains all Hipparcos stars for which astrometric and magnitude values are assigned, and all additional non-redundant entries from the Tycho-2 catalog except multiple-component entries. There is a total of some 2.5 million stars, or about 60 stars per square degree.

One example of a star with high proper motion is Groombridge 1830 (HD 103095), in Ursa Major, near 11h53m 37d44m. For a nice discussion see Burnham's Celestial Handbook, Volume III, page 1978. By comparing its position in either PM catalog with the same entry from the GSC one can deduce this particular GSC field was evidently taken in early 1983.

Skip likely duplicates:
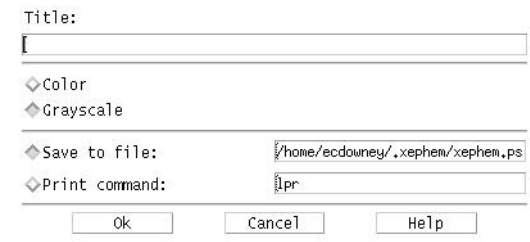
All of the above may be used together with the regular database facility of XEphem. If this option is on, XEphem eliminates what appears to be redundant entries for the same star from the various catalogs. Two stars are considered the same if their positions match within 4 arcseconds and their magnitudes differ by less than 3. (The generous magnitude tolerance is because the GSC and the PPM use varying filters). When deciding on the final selection for such duplicate entries the highest priority is the local database, then the HD or SAO entry, then the PPM entry, then Hipparcos, then Tycho and finally the GSC entry.

When you have made the desired entries, pressing **Apply** will attempt to check each filename, directory and Internet choice, as appropriate. The cursor will be a Watch while the tests are in progress. If something does not seem correct, a warning window will appear and the option will be turned back off. If everything seems to be operating correctly, you are in business. The Ok button does the same thing but then also closes the window if they all succeed. If at any time during normal operation something goes wrong during the acquisition of any Field Stars or FITS files from any View, the responsible option in that view is also turned off automatically.

All field star sources will silently enforce limits on the total number of stars they yield for any query. As of this writing, local queries are limited to 15 degrees; network queries impose their own limits; FITS and DSS images are limited to sizes of 20 arcminutes or smaller.

Data

14 Print

This window lets you print the current view or save it to a file. In either case the format used is Postscript.

If you enter a string in the text field labeled Title, the string will be printed centered across the top of the page.

The top two toggle buttons allow you to choose whether color commands will be included in the Postscript generated.

If you choose to **Save** to a file, turn on that toggle button and type the desired file name in the text box to the right of the toggle button. The file name will be relative to the directory from which XEphem was executed or you may precede the file name with "~/" to refer to your home directory.

If you choose to print directly to the printer, turn on that toggle button and type a command which will print a Postscript file on your system. The command should expect the name of a file to print as its first and only argument. A temporary file will automatically be created for this command and deleted when printing is completed.

When ready, press **Ok**. To avoid printing, press **Cancel**.

If your current viewing fonts are not available for printing, error recovery will depend upon your local print system.

15 Trails

This window allows you to define a set of time values spaced at regular intervals beginning at the current XEphem time and define which and in what manner values will be annotated with a time stamp.

This is a general purpose facility used in several places throughout XEphem, generally for the purpose of establishing a trail of object motion. This description will be of a general nature. For the specific information on how a given XEphem view uses these time values, please refer to the Help information associated with that view.

Seven parameters must be specified:

Orientation:

This choice determines Where the stamps appear in relation to their corresponding tick mark.

The radio box in the upper left corner provides several strategies for placing the time stamps near each tick mark. The first several options should be obvious. The last two, "Path-left" and "Path-right", cause the time stamps to be placed to the left or right side of the trail path, as one would perceive these directions when traversed in forward order. In no case are the time stamps ever drawn to require you to turn your head more than 90 degrees left or right.

Interval:

This is the time interval between each step.
Choose from among the several handy intervals in the upper central radio box, or choose Custom and enter any desired interval in the space provided. It is okay to specify more than 24 hours to achieve intervals of several days. It is also okay to specify negative values to run time backwards.

Label:

> This choice determines which intervals will to be label with a time stamp.
> Choose from among several options in the upper right radio box, or choose None if no labeling is desired.

Format:

> This choice determines how to display each time-stamp.
>
> The lower left radio box offers either Hour:Minute format or the current date Preference (as set in the Preferences->Date formats option in the Main menubar).

Font:

> This choice sets the size of the annotation text font.
>
> The bottom central radio box allows you to choose from several character sizes for the time stamps.

Start:

> This choice specifies how the first time value is derived from the current XEphem time.
>
> The lower right radio box offers several methods of determining the beginning of the first time interval. "Whole min" rounds the current XEphem time forward to the next whole minute, if necessary; "Whole day" rounds to the next whole day. "Whole interval" rounds to the next whole multiple of whatever time interval is set (as specified in the Intervals choices). "Now" means to begin with the current XEphem time without any initial changes.
>
> The idea here is generally to match the time values of each time mark with the precision implied by the format, but to allow other options as necessary.

Number of tick marks:

> This is specified by setting the scale near the bottom of the dialog to the desired number.

Once the choices are set up as desired, **Ok** will create the trail and the dialog will disappear. **Apply** will create the trail but the dialog will remain up for further use. **Close** just dismisses the dialog without creating a trail. **Help** brings up this message.

Even with all this flexibility pleasingly annotated trails are not trivial to generate. It is hoped that a little experimentation can yield acceptable results in most cases.

Note that this general trail facility does not provide close coupling with the view being supported. For example, some views do not support setting a trail for an object which has changed while the Trail Setup is up. Also, views may vary in their support of having trails defined while they are not visible. Each view may establish its own initial default values but changes usually remain in effect for subsequent instances of Trail Setup dialogs from the same view. Some views permit more than one Trail Setup to be active at one time. In short, the operational boundary conditions vary by view.

16 Meade LX200 Support

This chapter describes how to operate a Meade LX200 (or compatable) telescope from XEphem. The discussion here applies to all platforms. See the Installation chapter for any issues on a particular platform. Also refer to the Telescope Configuration window for configuration details (§10.6).

16.1 Disclaimer

Before going any further we must make some things perfectly clear. We believe the information provided here and the functionality provided by our software will perform in a satisfactory manner. However:

CLEAR SKY INSTITUTE INC IS NOT RESPONSIBLE FOR ANY DAMAGE CAUSED TO YOUR EQUIPMENT UNDER ANY CIRCUMSTANCES WHATSOEVER. <u>USE AT YOUR OWN RISK.</u>

We also wish to make it clear that this work was performed independently of and is **not** endorsed by Meade Instruments Corporation. Their "only" contribution was to build a great amateur robotic telescope and provide for its computer control.

16.2 Cable

For handy reference, below is a diagram showing the basic wiring of the cable between the LX200 RS232 port and a female DB9 connector suitable for connecting to COM1 on most PCs. Note that although the the LX200 accepts a 6 pin connector, the outter two leads are not used, so a common telephone-style 4-pin connector may be used.

RJ45
Looking down with clip beneath.

DB9 Female
looking at finished end.
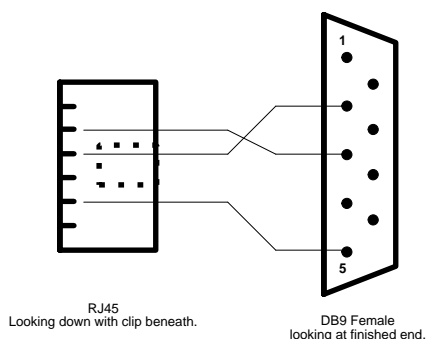
For more information, try the following web sites:

```
http://www2.crl.go.jp/ka/tnp/meade/cable.html
http://www.mapug.com/AstroDesigns/MAPUG/Battery2.htm#anchor2189857
```

16.3 Routine operation

With the LX200 powered and connected, *lx200xed* running, and the Marker turned on in the Sky View, you should see the telescope target symbol at the same RA and Dec reported by the LX200 hand paddle display. The Sky View will automatically reposition itself as necessary in order to keep the marker visible. If the cursor is outside the Sky View, the coordinates of the marker are shown in the upper corners.

To move the telescope, put the cursor over a sky location to which you would like to point the telescope and press the right mouse button. A popup will appear. Without letting go, slide down to **Set telescope** and release. This should send a command to the LX200 to move to that location and commence tracking. You can watch it move on the Sky View as the marker is updated.

That's about all there is to it. Just point and go. Or if you just want to move your LX200 by hand or with its own control paddle you can just watch where it is pointing on the Sky View.
If you want to aim the Sky View somewhere other than at the telescope, turn off the Marker in the Telescope menu first or else it will keep bouncing back to keep the Marker in the field; then turn it back on later when you again want to see where the telescope is pointing. In anticipation of not wanting this locking-on behavior, the Telescope Marker is automatically turned off if you use the Locate menu, use the Center or one of the Zoom buttons in the popup menu, or use one of the Sky Point controls found elsewhere in XEphem (such as the Data->Search window, §13.3). During all this Marker on and off business, there is no need to kill and restart *lx200xed*; it will just stand by for XEphem to reconnect.

Note: The computer and the LX200 keep separate notions of time and Earth location. The software makes no attempt to change these on either side. The closer you make these in sync, the more similar XEphem and the LX200 paddle will report information. We have found that if the SIDE and LOCAL values on the paddle match the Sidereal time and Lat/Long, the time and date agree, refraction is turned off in XEphem (by setting an air pressure of 0), XEphem Epoch is set to 2000, and XEphem is set to update its time about every 2 seconds or so, then the LX200 and XEphem will agree in all reported values to full display precision. There will always be one difference however: XEphem uses North as 0 degrees Azimuth, whereas the LX200 uses South; thus they will always differ by 180 degrees.

17 Notes

1) The program uses a horizontal plane tangent to the Earth Elev feet above sea level as the horizon for all altitude calculations, rise/set events, etc. Due to Earth's curvature, this is not the same as the angle up from the local horizon unless the observer is directly on the ground. The effect can be found from:

$$\sin(a)^{**}2 = (h^{**}2 + 2Rh) / (R+h)^{**}2$$

where:
   R = radius of earth
   h = height above ground (same units as R)
   a = increase in altitude

The effect is remarkably significant. For example, it is more than two arc minutes at a height of 5 feet.

2) Libastro is based on VSOP87. For Mercury, Venus and Mars the accuracy of this model rises to 1" at the ends of the year range 2000 +/- 4000. For Jupiter and Saturn, the 1" range is 2000 +/- 2000. For Uranus and Neptune, it is 2000 +/- 6000. For the Moon, 1" accuracy is for the range -1369 to +2950.

Other heliocentric objects are well within one arc minute at the time of the epoch of their elements; this steadily worsens with time since XEphem does not apply perturbations.

Using a GPS position locator and transit, I have independently verified Sun and Moon limb rise and set times are accurate to within one minute and azimuths are with about 0.1 degree.

3) The Sun-Moon distance is the solution for the third side of a planar triangle whose two other sides are the Earth-Moon distance and Earth-Sun distance separated by the angle of elongation.

4) The visual magnitudes for the planets take into account the phase of the illumination; the magnitudes for other solar system objects do not.

5) The following is the current TODO list of ideas for XEphem. Thanks to all who have made suggestions. Please let me know your priorities or suggest more.

 + write a tool to find g/k from a set of predicted magnitudes.
 + add undo for plot and listing selections.
 + display occultation path between *any* two objects in the Earth view
 + show correct Moon and Planet phases and orientation in Sky View.
 + add sidereal day and month trail intervals.
 + just label month and year tickmarks in trails when they change
 + comet tail pointer
 + meteor showers, (dedalus)
 + Iridium flares
 + allow using a tracked object as the reference for a trail
 + arbitrary solar system perspective
 + option for rise/set info to be Today or Next.
 + add "Plot JD as years" to plot display
 + add H:M:S trails Format option
 + way to keep list close pairs while looping
 + way to keep skyview listing ongoing while looping
 + add general text and graphics annotation for all views, with save.
 + use better earth shape model (at least an oblate spheroid)

Notes

+ add separate Sol view with real-time Net sunspot and coord grids.
+ add T->F and F->T to Binary, min/max to Extreme and stop when T/F or <0/>0
+ Jupiter satellite shadows
+ use user-defined horizon for rise/set calculations
+ some means to automatically print while looping (PS multi-page format?)
+ interactive way to create user-defined horizon, with labeling.
+ way to repeat the Solver for more solutions, as in "solver in a loop"
+ support Sloan and GSCII when complete.
+ change to an XML database format, then add real doubles, variables, etc
+ set an ROI in sky view and click an object to ask "when will it be in box"
+ more hot-keys
+ more flexible time stepping

Known Bugs:
- Pref->Zone should apply everywhere.
- Pref->Zone does not update dates of FM/NM if they happen to squirm.
- constellation figures could stand some improvement.
- length of night wrong when savings time causes dusk after midnight
- center constellation names based on boundaries rather than on figures
- solar trails don't account for long-term (10's of years) precession
- changing font shrinks sky and Earth views unless their view has changed once
- plot's View settings are not Saveable.
- trails are not always clipped properly against a user-defined horizon
- alt/az grid at dec +/-90 (and v.v.) is crazy
- use Crenshaw's method for more stable minimax solver algorithm

18 Credits

First and foremost, many thanks to my wife, Kathy, for her unwavering trust, acceptance and support; aka, Love.

Beyond that, the following are in no particular order but all are greatly appreciated:

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Earth satellite orbit propagation is based on the NORAD SGP4/SDP4 code, as converted from FORTRAN to C by Magnus Backstrom, b@eta.chalmers.se. See "Spacetrack Report Number 3: Models for Propagation of NORAD Element Sets" at http://www.celestrak.com/NORAD/documentation/spacetrk.pdf.

Improvements to Delta T code, help and wording contributed by Neal McBurnett, nealmcb@bell-labs.com.

Any parts of the USNO SA2.0 catalog that are included with XEphem distributions are done so with the following understandings:

It may not be the latest version, check with http://ad.usno.navy.mil.

If you paid for XEphem, you paid for the software, not this catalog. The catalog is available free from the USNO.

Inclusion of the SA2.0 catalog does not imply an endorsement of XEphem by USNO; nor did I have privileged access to the catalog; nor does the US Government affirm or guarantee that XEphem works properly in any way.

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The near real-time weather map in the Earth view is provided by the Space Science and Engineering Center at the University of Wisconsin. See their web site at http://www.ssec.wisc.edu/ssec.html.

The XEphem logo was contributed by Jonathan Adams, jfadams@mail.arc.nasa.gov. The galaxy background image is from Galaxy Photography, www.galaxyphoto.com.

For the years 1999-2010 the natural satellite ephemerides for Mars, Jupiter, Saturn and Uranus are based on developments in mixed functions computed and contributed at Bureau Des Longitudes, http://www.bdl.fr, by J.-E. Arlot, Ch. Ruatti and W. Thuillot. Many thanks! The authors state these are generally good to 1/2 arcsecond accuracy. In my test against JPL DE405 I would say this is true about 50% of the time, with a worst case of about 4 AS.

Outside this range, Jupiter's moons based on information in "Astronomical Formulae for Calculators" by Jean Meeus. Richmond, Va., U.S.A., Willmann-Bell, (c) 1982. Saturn's moons based on code and ideas supplied by Dan Bruton, Texas A&M, astro@sfasu.edu. For all dates, ring tilts based on "RINGS OF SATURN" program by Olson, et al, Sky & Telescope, May 1995, page 95. C code as converted from BASIC by pmartz@dsd.es.com (Paul Martz).

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Many formulas and tables are based, with permission, on material found in: "Astronomy with your Personal Computer" by Dr. Peter Duffett-Smith, Cambridge University Press, (c) 1985.

The high precision planet positions were implemented for XEphem by Michael Sternberg <sternberg@physik.tu-chemnitz.de> based on the papers

"Planetary Theories in rectangular and spherical variables: VSOP87 solution" by Bretagnon P., Francou G., in Astron. Astrophys. 202, 309 (1988), ftp://ftp.bdl.fr/pub/ephem/planets/vsop87/, and

"Representation of planetary ephemerides by frequency analysis. Application to the five outer planets" by Chapront J., Astron. Astrophys. Suppl. Ser. 109, 181 (1995), ftp://adc.gsfc.nasa.gov/\ pub/adc/archives/journal_tables/A+AS/109/181.

See the comments in chap25.h and vsop87.h for accuracy estimates.

The high precision Moon code was also implemented for XEphem by Mr. Sternberg based on code supplied by Stephen L. Moshier <moshier@world.std.com> at ftp://ftp.std.com/pub/astronomy/selenog.zip. Mr. Sternberg also incorporated the algorithm for deltaT, based on code also provided by Mr. Moshier. See the comments in deltat.c for full references. My greatest thanks to Messrs. Sternberg and Moshier for their generous and kind assistance in making XEphem a program of first-class accuracy.

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Rotated trail text uses the xvertext package. Here is the copyright:

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IC.edb was submitted by Christos Siopis, siopis@astro.ufl.edu.

Constellation algorithm is from a paper by Nancy G. Roman, "Identification of a constellation from a position", Publications of the Astronomical Society of the Pacific, Vol. 99, p. 695-699, July 1987. Further contributions from Chris Marriott and Ernie Wright. The list of boundaries is derived from the three files constell.1875.data, constell.1875.hdr and constell.doc at ftp://explorer.arc.nasa.gov/pub/SPACE/FAQ/.

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The Earth map is derived from data supplied with xearth which included the

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Most of the sample cities in the "xephem.sit" file are from the xsat program, which included the following notice:

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Most of the sample observatories in the "xephem.sit" file are transcribed, with permission, from the table beginning on page 28 in the July 1993 issue of Sky and Telescope. Any errors in transcription are strictly my own.

Thanks to Lowell Observatory and the Minor Planet Center for maintaining
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Elwood Downey
ecdowney@ClearSkyInstitute.com

Credits

19 About

Index

Index