XEphem

pronounced *eks i fem´*

Version 3.7.3

Reference Manual

1 Introduction

XEphem is a scientific-grade interactive astronomical ephemeris package. XEphem:

- 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.
- provides special efficient handling of **large catalogs** including Tycho, Hipparcos, GSC.
- displays data in **configurable tabular formats** in conjunction with several interactive graphical views;
- displays a **night-at-a-glance** 24 hour graphic showing when any selected objects are up;
- displays **3-D stereo Solar System views** 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**;
- creates **plots of any pairs** of all data fields throughout the program;
- downloads **current asteroid and comets** ephemerides from Lowell Observatory and Minor Planet Center;
- downloads timely **Earth satellite** orbital TLE parameters;
- plots true **binary system** orbits;
- downloads **Digitized Sky Survey** FITS files from STScI or ESO;
- provides a handy **coordinates spreadsheet** for converting among equatorial, ecliptic, horizon and galactic frames ;
- displays live SOHO images of the **Sun**;
- includes a compiler for entering and **solving user-written functions** using any data fields;
- serves as the control point for **GOTO telescopes** such as Meade LX200 or other external applications;
- displays FITS files **images overlaid** with database symbols and other graphical information;
- performs automatic star pattern matching to **automatically solve for World Coordinate System** on any image;
- performs 1-click 2D Gaussian relative and absolute **photometry;**
- defines and saves any number of **Eyepieces** to use in sky maps;
- captures, displays and clips to any number of **local horizon profiles**;
- stores sets of all Sky View options in **history** sets for easy playback later;
- prints using high quality **Postscript**;
- allows you to assign any number of objects as **Favorites** for special fast access throughout the program, and makes them available even when their original databases are no longer loaded;
- provides an extensible **image gallery** initialized with over 300 beautiful and informative color images of deep sky objects;
- provides an **observing logbook** which is automatically filled in with observing circumstances, with searching on most fields;
- displays **magnetic deviation** for any location.
- create **movie loops** of any View, NAAG or Plot window.

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.

1.1 Quantitative information

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 Favorites.

1.2 Local circumstances

Local observing circumstance information includes

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

Equatorial coordinates may be computed in any four combinations of 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.

1.3 Launching XEphem

In addition to all the standard X Window System command line arguments, XEphem also supports the following command line arguments:

Argument	**Meaning**
-env *name*=*value*	set internal value for environment variable; any number allowed
-help	print this then exit
-install {yes no guess}	whether to install a private colormap, default is guess
-log	save exit trouble to private log
-nosplash	disable splash screen from now on
-nowin	do not restore windows
-prfb	print all internal default resources then exit
-resfile *f*	load alternate X resource file
-splash	show splash screen from now on

1.3.1 Shared and Private Directories

When XEphem is launched it looks for a file named `.xephemrc` in the user's `$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 look for *Private* files, so-called because on a multiuser system they are expected to be separated on a per-user basis. A leading "~" in the file name can be used to refer to `$HOME`, your login directory. A leading "." in the file name can be used to refer to the current working directory of the running program. The example above causes the Private directory to be `.xephem` in the users `$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 for *Shared* files. This directory contains files presumed to 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` which may be located in any of the standard X Window System directories, in /etc or within the Private directory (see above). It should contain a line with the following form:

```
XEphem.ShareDir: /usr/local/xephem
```

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. Internal defaults may be printed using the -prfb command line option.

1.3.2 Main window control

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.

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.

You can change time manually like any other fields or you can set up looping to advance time automatically with specified pauses between each step. The prominent button at the bottom of the Main window labeled **Update** causes all other windows throughout XEphem will be recomputed with the new time. Looping effectively presses this button for you. See Looping.

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 size 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.

1.4 Time and angle formats

Time and RA are displayed as h:m:s. They may be entered the same way or the color (:) may be entered as slash (/) semicolor (;) comma (,) or space. Other angular quantities, such as declination, azimuth, altitude, longitude and latitude, are entered and displayed as d:m:s but otherwise use the same rules.

Components of a sexagesimal field may be entered as floating point numbers. For example 10:20:30 may also be entered as either 10:20.5 or 10.34167.

Negative values are indicated by one hyphen (-) before the first character.

Dates are entered and displayed in any one of the forms month/day/year, year/month/day or day/month/year, depending on the Preferences selection on the Main menubar. The slash (/) may also be entered as hyphen (-) semicolon (;) or comma (,). Note you must always enter the full year.

When the day portion of a date is an integer, the time does not change. When the day portion of a date is entered as a floating point number, the time will also change to correspond to the fractional portion of the day. For example, using the preference m/d/y, entering a date of 1/1.5/1995 will set the date to 1/1/1995 and the time to 12:00:00. To get this effect with a whole day, include the decimal point. For example, 1/1.0/2002 will set the date to 1/1/2002 and the time to 0:00:00.

You may also enter a date as a decimal year, as in 1990.12345.

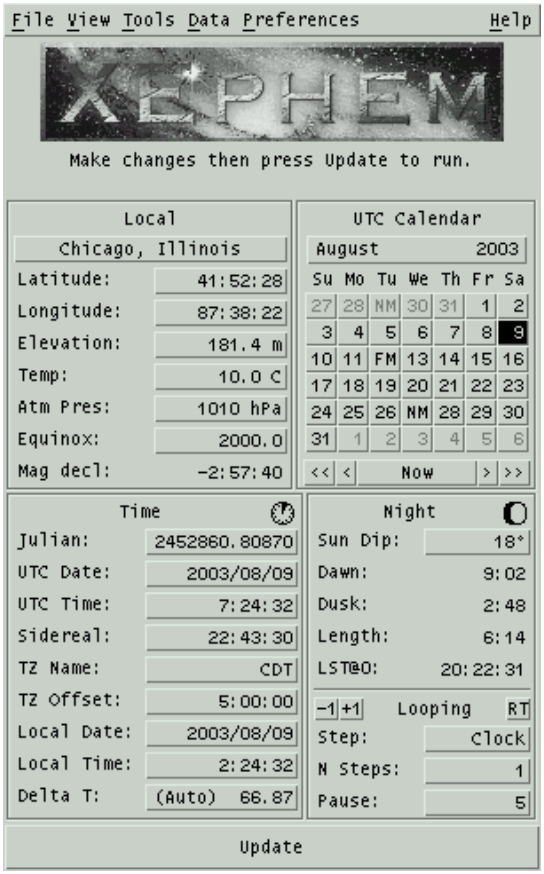
Negative years indicate BC dates. For example, Jan 1, 1 BC is given as 1/1/-1. Before you ask, yes, "1-1--1" works for 1 BC. There is no year 0.

2.0 Main Window

XEphem's main window is divided into five regions plus the menu bar across the top for selecting the principle functions of XEphem. Each window opened from the menu bar has its own Help.

Beneath the XEphem logo image is a status line that contains a short description of what XEphem is doing at the moment with regards to its looping behavior.

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.



2.1 Main's Help menu

XEphem help is written in html version 4.01 transitional and requires a browser to read. The text is all in one file, xephem.html, located in auxil/help within the Shared directory path. Anchors throughout the file allow XEphem to specify exactly where to jump for each Help entry.

`Help » Configure`

This Help entry is used to set how XEphem sends a URL to your browser. It must be correct before any other Help can be used. It displays a table showing sample shell commands that accomplish this for several popular browsers including mozilla, netscape, opera, konqueror and safari. Each time %s appears in the definition the full path to the xephem.html will be substituted. If you figure out how to configure for another browser or you know of a better definition please send us your results and we will post on our web site.

Note the entry for using IE under cygwin. In order for this to work, you must create an environment variable before running XEphem named XEHELPURL set to the full Windows path of the xephem.html file using Windows filespec notation. The value of this variable is substituted for each %s appearing in the definition for IE.

`Help » on Context`

This Help entry turns the cursor into a Question Mark. Roaming the cursor over any control in XEphem will show its bubble help tip whether or not the tips Preference is active. Press the left mouse button to end this behavior and resume normal operation.

All remaining Help entries just bring up additional information as one would expect. If you are new to XEphem, we suggest you begin by reading the next three entries in order, Introduction, Operation and Triad formats, then feel free to explore.

2.2 Menu bar

2.2.1 File

- **System log...** displays a scrolled list of informational messages and alert. XEphem may beep whenever a new message is added, depending on the Log Bell preference. See System log.
- **Gallery...** displays a list of installed color images and allows browsing or marking in Sky View. See Gallery.
- **Network setup...** displays a window offering choices for how XEphem accesses the Internet. See Internet.
- **External file...** drives XEphem from a file containing times and latitude/longitude locations. See External input.
- **Progress Meter...** displays a simple bar graph of XEphem progress. The accuracy and usefulness of the display are somewhat 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. **See** Looping.
- **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.

2.2.2 View

The View menu gives access to all of the several XEphem specialized displays.

- **Data Table...** highly configurable, show any from a selection of over 30 parameters for each Favorite object. See Favorites and Data table.
- **Sun...** show SOHO images of the Sun, measure current RA and Dec of solar features. See Sun.
- **Moon...** show real lunar image, mark hundreds of natural and artificial features, compute sun and observing circumstances. See Moon.
- **Earth...** show spherical or cylindrical projection, satellite ground tracks. See Earth.
- **Jupiter...** show planet image with moons and shadows. See Jupiter.

- **Saturn...** show planet image with moons and shadows. See Saturn.
- **Uranus...** show planet symbol with moons. See Uranus.
- **Sky View...** the showpiece of XEphem, display maps, images, trails. See Sky View.
- **Solar System...** 3D and perspective diagrams include asteroids, comet trajectories. See Solar System.

2.2.3 Tools

The Tools menu gives access to windows allowing full control of the following functions:

- **Plot values...** plot pairs of any data values shown throughout XEphem. See Plotting.
- **List values...** print columnar lists of any data values shown throughout XEphem. See Listing
- **Solve equation...** define and solve any mathematical function using any data values shown throughout XEphem. See Solver.
- **Find close pairs...** search all loaded database objects and sort all pairs by increasing separation. See Close pairs.
- **Night at a glance...** display when all Favorite objects are up over a 24 hour period. See Night at a Glance.
- **Coordinates converter...** enter one of equatorial, horizon, ecliptic or galactic coordinates and show the others. See Coordinate converter.
- **Observers log book...** click on a target in Sky View to fill in standard observing fields, add your own notes and save, later browse or search for entries. See Observers logbook.

2.2.4 Data

The Data menu gives access to windows which pertain to managing the objects in memory.

- **Files...** 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. See Data Files.
- **Index...** searches and displays all information about any given object in memory. Also can be used to center the Sky View over any object. See Data Index.
- **Favorites...** adds, enables, sorts and deletes the set of objects you wish to have easy access to. See Favorites.
- **Internet...** provides a convenient means to update XEphem databases from the Net. The window comes preconfigured to get timely asteroid, comet and Earth satellite catalogs. See Internet.
- **Field stars...** sets up how and whether to read several very large databases of faint stars which XEphem refers to as "field stars See Field stars.

2.2.5 Preferences

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 simple preferences 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

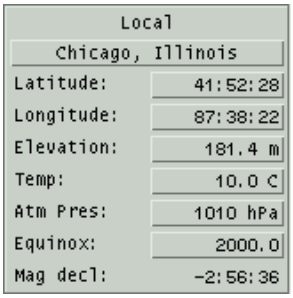
format only and does not imply a change in accuracy.

- **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. See System log.
- **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 fonts.
- **Colors...** displays a window to experiment with colors while you watch. See colors.
- **Save...** displays a window which shows how the current functional settings differ from their defaults and allows them to be saved. See save.

2.3 Sections

The Main window is divided into five basic sections.

2.3.1 Local

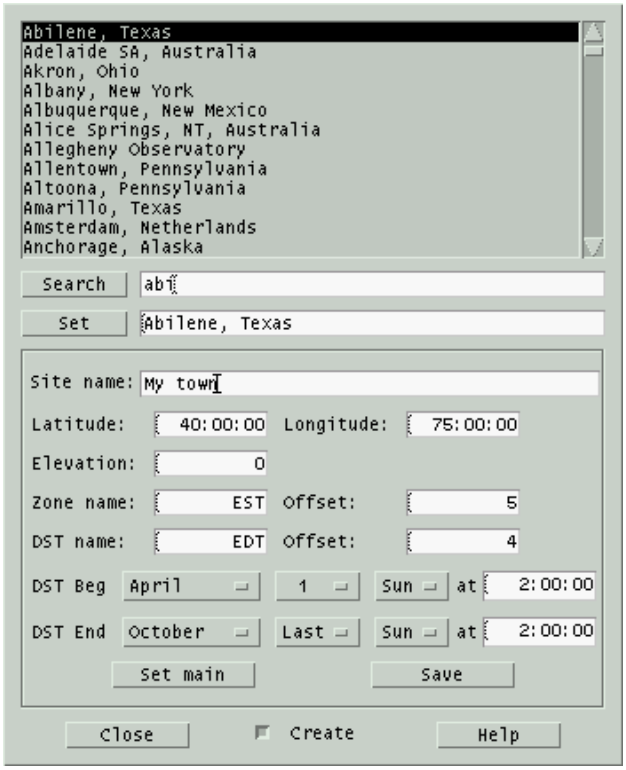


- **[Site name]** Above the Latitude field is a button which can display the current site name. Pressing this button will bring up a list of cities and observatories. See Sites.
- **Latitude** Local geographic latitude, positive degrees north of equator. Changing this will disable automatic computation 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.
- **Temp** Local surface air temperature, in °F or C. Used in refraction correction.
- **Atm Pres** Local surface air pressure, in inches of mercury or hPa. 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.

- **Mag decl** This is the amount by which the horizontal component of the Earth's magnetic field varies from true north. Put another way,true az = magnetic bearing - mag decl. The model is stored in the file wmm.cof in the auxil directory of the shared directory. It is valid for 2000 through the end of 2004. Check http://www.ngdc.noaa.gov/seg/potfld/DoDWMM.shtml for updates.

2.3.1.1 Site Selection



This window allows you to search, load and add to 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 type a glob pattern 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 matches the search text.

Creating new sites.

Clicking **Create** expands the dialog to add fields for creating new sites. Fill in the fields then click **Set main** to test the entry and **Save** to add it to the collection on disk.

File format:

XEphem stores sites in the file named **xephem_sites**. One may reside in either or both the Shared and Private directories. The Sites window always checks both.

Each line in the file consists of 5 fields, each separated by a semicolon (;):

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 details of savings time formatted as follows:

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

There are no spaces in the specification. All fields except the initial `std` string are optional. It specifies the name of the standard time zone and must be three or more alphabetic characters.

The `offset` string indicates the value added to the local time to arrive at Coordinated Universal Time. The offset has the format `hh[:mm[:ss]]`. The minutes (mm) and seconds (ss) are optional. If preceded by a minus (-) the timezone shall be east of the Prime Meridian; otherwise, it shall be west (which may be indicated by an optional preceding plus (+)).

The `dst` string and second `offset` specify the name and difference between the daylight savings time zone and the standard time zone. If the offset is omitted, it defaults to one hour ahead of standard time.

The `start` field specifies when daylight savings time goes into effect and the `end` field specifies when the change is made back to standard time. These fields have the format `Mm.w.d` which specifies day d (0 <= d <= 6) of week w (1 <= w <= 5) in month m (1 <= m <= 12). Day 0 is Sunday. Week 1 is the first week in which day d occurs and week 5 is the last week in which day d occurs. If omitted, Savings time will begin the first Sunday in April and end the last Sunday of October.

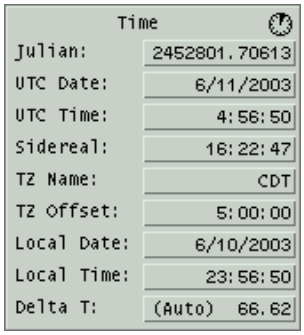
The `time` fields specify when, in the local time currently in effect, the change to the other time occurs. If omitted, the default is 2:00:00.

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.

2.3.2 Time



- **Julian** Number of days since noon 4713 BC to about 1-second accuracy. Used as a uniform time scale.
- **UTC Date** The UTC date. UTC is Universal Coordinated 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.
- **Sidereal** The apparent sidereal time for the current time and location. Equals the apparent RA at the local meridian.
- **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 date minus the value of TZ Offset.
- **Local Time** The local time. This is UTC time 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

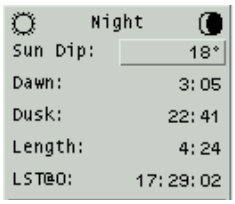
computed automatically based on the current time or entered manually (in which case it will not change). The algorithm uses values tabulated in the Astronomical Almanac for years 1620.0 through 1998.0, and is accurate to within a few seconds over that interval. Dates prior are from Stephenson and Morrison or K. M. Borkowski, with an estimated error of 15 minutes at 1500 B.C. A linear extrapolation formula predicts future values.

2.3.3 Calendar

The calendar on the right of the Main window is based on local time or UTC, depending upon the Time Zone preference. Clicking a date button will set the date. Clicking dates before the first of the month and after the last of the month will also change month or year as necessary. The month and year buttons pop up menus that allow these to be changed as well. At the bottom the **Now** button sets the time and date to the computer clock. The arrow buttons 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.

2.3.4 Night



- **Sun icon** When the sun is above the local horizon a small sun symbol is drawn in the upper left corner of this section.
- **Moon icon** When the moon is above the local horizon a small symbol is drawn in the upper right corner of this section depicting the approximate phase of the moon. The brighter of the foreground and background colors is used to draw the portion in sun light.
- **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 (can just tell whether headlights are on),
  - 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.

2.3.5 Looping

- **-1 +1** These are shortcuts to go backwards or forwards by one Step. Can also

be performed by typing Control-b and Control-f from any window.

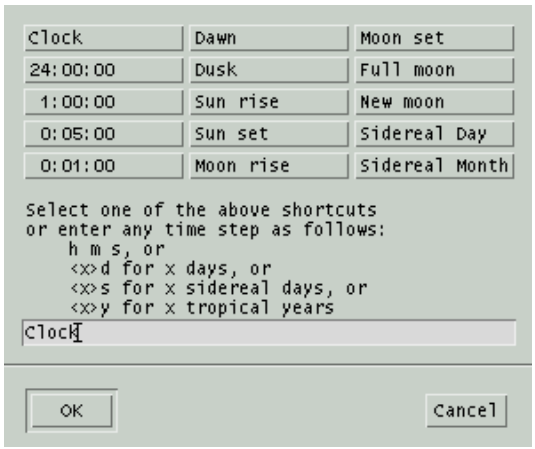
- **RT** Clicking this button will synchronize XEphem to the computer clock and commence Updating every Pause seconds. If Pause is 0 when this is started, it will be set to 10 seconds. This can be the initial mode for XEphem by saving the AutoRT Preference. RT is really just a shortcut for:

  1. clicking Now under the calendar
  2. setting Step to Clock
  3. setting N Steps to something large and then
  4. clicking Update.

- **Step** The interval by which, or event to which, time is changed each loop. Fixed intervals are specified in hours, minutes, seconds, days and years or time may be set to advance to an event such as the next sun rise, dawn or full moon.

- **N Steps** The number of times the display will be updated (time advanced by Step each step) automatically. When Update is clicked, this number counts down until it reaches zero then is reset to one.

- **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,listing or solving are active. When looping, time is maintained at a whole multiple of pause length.

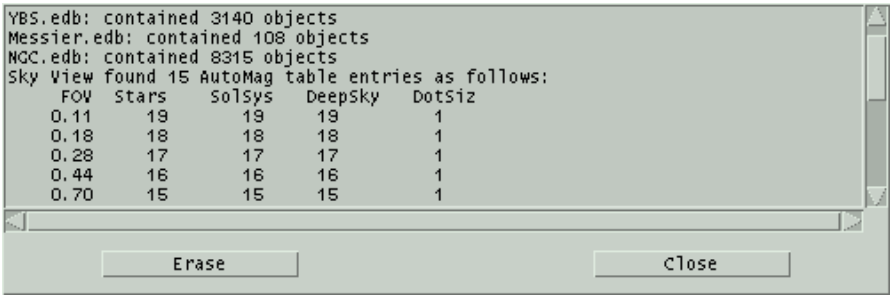


When looping is in effect, the label on the bottom button changes to **Stop**. When the number of steps goes to 0 or the Stop button is clicked the looping stops and the button label changes back to **Update.**

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

3.0 File menu

3.1 System log



This window contains additional information from XEphem. Whenever an entry is written the computer may beep, depending on the setting of the **Log bell** Preference. The contents of all Alert windows are also written here. Scroll bars to the right and below allow panning through the log.

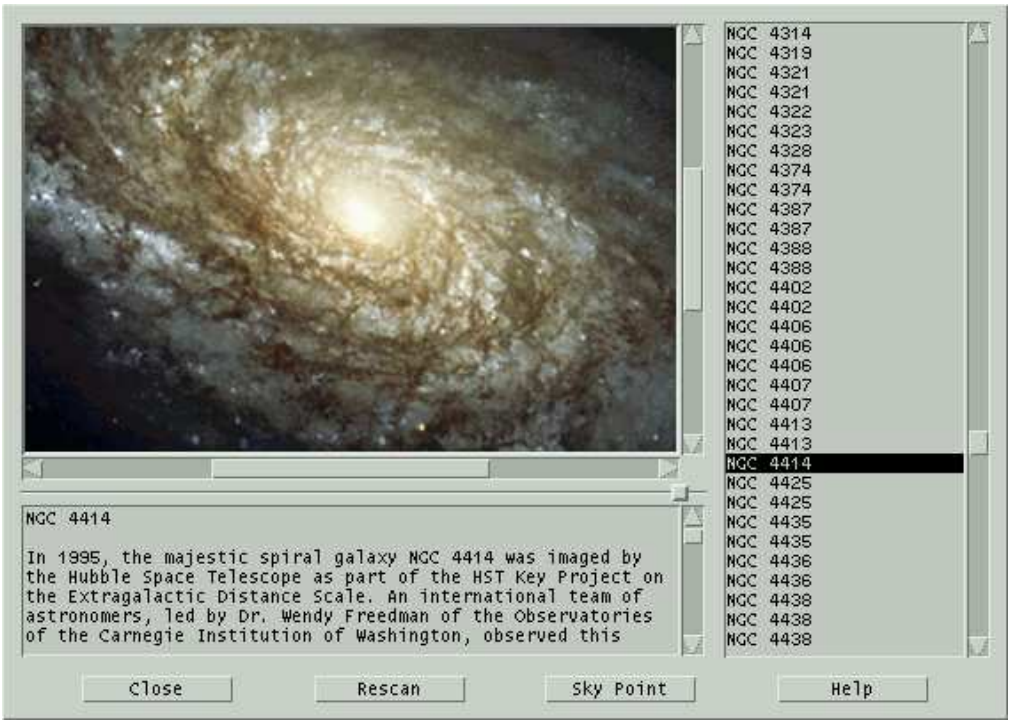
Erase

Permanently discards all log entries.

Close

Closes the log window but has no effect on its contents or ability to capture further information.

3.2 Gallery



This window is a portal to high quality color images.

The Gallery window is broken into three sections. Down the right side is a scrolled list of the available images. Images are displayed in the upper left, captions in the lower left. All sections scroll to accommodate large areas. A sash between the upper and lower sections on the left allow you to control the proportion of vertical space used by each.

Controls across the bottom:

Close

Close the Gallery window.

Rescan

Reinitialize the list. This also occurs each time the Gallery window is opened.

Sky Point

If the current XEphem database contains an object whose name matches the Gallery object currently being displayed, this button will be active and clicking this button will center the object in the Sky View.

3.2.1 File format

The Gallery database index is stored in one or more files with the suffix **.gly**. The index files and the image files to which they refer reside in a directory named **gallery** which in turn must reside within either the Shared or Private directories. All index files found are combined and sorted by name into the scrolled list.

The index file is in XML format. The entire collection is within one outer-most element named `gallery`. In turn it contains one element named `image` for each Gallery image file. In turn it contains one or more elements named `name`, one element named `file` and one element named `description`. The file name is with respect to the directory in which the .gly file resides. When XEphem reads the description contents, it replaces isolated newlines with blanks so that word wrapping is left up to the scrolled text window. Please refer to the following example.

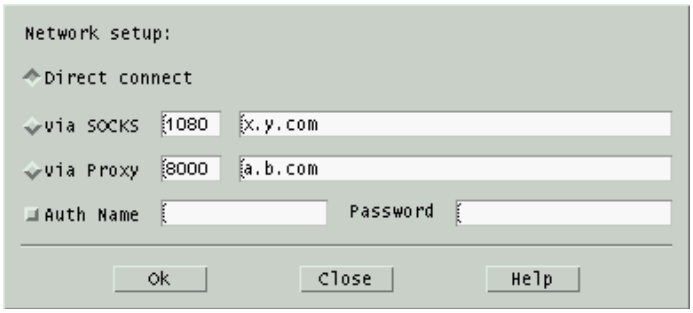
```
<gallery>
    <image>
        <name>
```

```
            NGC 4414
        </name>
        <file>
            1999-25-a-web_print.jpg
        </file>
        <description>
In 1995, the majestic spiral galaxy NGC 4414 was imaged by the Hubble
Space Telescope as part of the HST Key Project on the Extragalactic
Distance Scale. An international team of astronomers, led by Dr. Wendy
Freedman of the Observatories of the Carnegie Institution of Washington,
observed this galaxy on 13 different occasions over the course of
two months.

Image Credit: Hubble Heritage Team (AURA/STScI/NASA)
        </description>
    </image>
</gallery>
```

3.3 Network Setup

This window controls how XEphem tries to connect to the Internet. One of the following three choices must be turned on for Internet access to be available.

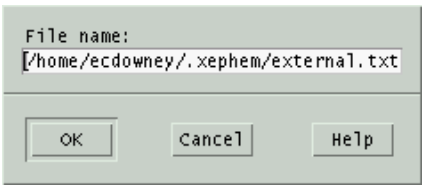


- **Direct connect** This choice just means to use the direct DNS/IP TCP/IP sockets as necessary. Use this one unless you are behind a firewall.
- **via Proxy** This choice attempts to access the Internet via a Proxy. Type the port address and the host name of the proxy in the fields provided.
- **via 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 fields provided. These values can be initialized using the environment variables SOCKS_PORT and SOCKS_NS.

If your Proxy or SOCKS firewall require Authentication, turn on the **Auth** option and enter name and password in the fields provided. Note that only the Name field may be Saved.

3.4 External Input

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.



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

```
JD Lat Long
```

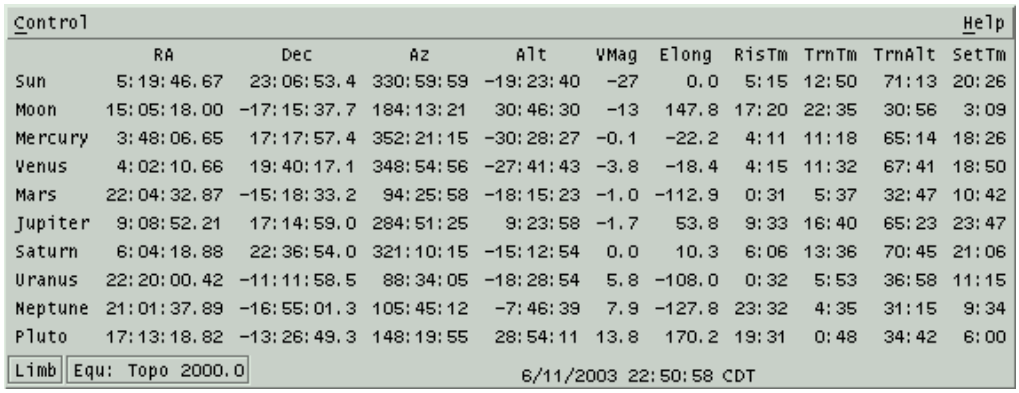
where

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.

4.0 View menu

4.1 Data Table



This is a table of information about each of the current Favorites. Each data item occupies one column in the table and each object occupies one row.

The Control pulldown menu contains the following options:

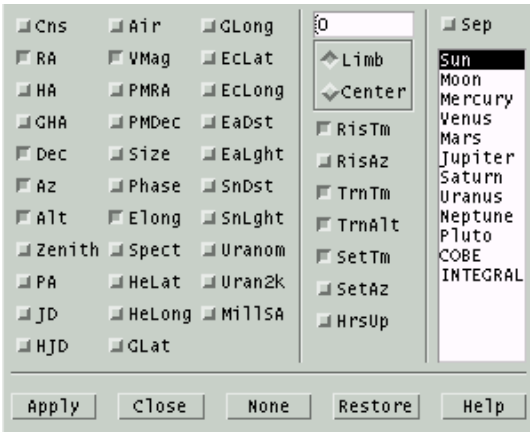
- **Setup...** This button brings up a configure window to specify the table rows and columns as desired.
- **List...** This button allows the current data table to be saved in a text file.
- **X Select** This button puts the current contents of the data table into the X11 PRIMARY selection buffer. You can then typically paste it into a file using the middle mouse button.

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.

Any of the information in this table may be plotted, listed or used in a solver algorithm.

4.1.1 Data setup

This window lets you configure which 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.



Entries are grouped into three sections for clarity. Column one 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** Greenwich 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.
- **PA** parallactic angle, i.e., the angle as seen from the target between zenith and NCP, measured positive westward of meridian.
- **JD** current UTC Julian date.
- **HJD** current heliocentric Julian date, i.e., JD adjusted to time frame of Sun.
- **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.
- **VMag** visual magnitude of object.
- **PMRA** Proper Motion in RA. Units are arcseconds/hour for a Solar system object, degrees/minute for an Earth satellite and milliarcseconds/year for all other types of objects.
- **PMDec** Proper Motoin in Declination. See PMRA for units.
- **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.
- **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.
- **Spect** Basic spectral classification, if appropriate.
- **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. Based on 32.93192° longitude of ascending node on equator, 192.85948° RA J2000 of North Galactic Pole and 27.12825° Declination of pole.
- **GLong** galactic longitude, in degrees. See GLat for definition.

- **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.

Section two 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 second Data Selection section:

- **RisTm** and **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** and **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** and **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 Zone Display 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, or displaying all its passes in the Night-at-a-Glance tool.

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.

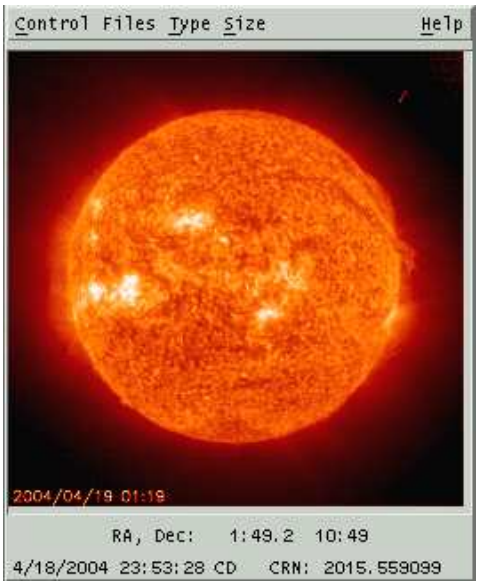
The third section in the Data Table setup window lists the current set of Favorites. Any one may be selected for which the angular separation between it and the object on that row will be shown, in degrees.

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.

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.

4.2 Sun



This window provides a convenient tool to download, display and manage images from SOHO, the Solar & Heliospheric Observatory. Use of this extraordinary data is courtesy of the SOHO consortium. SOHO is a project of international cooperation between ESA and NASA.

The SOHO data is pulled from the web site http://sohowww.nascom.nasa.gov. The host name is defined in the XEphem resource XEphem.SOHOhost. This may be changed if necessary by placing a new value in the XEphem resource file.

4.2.1 Sun mouse

Moving the mouse over a loaded SOHO image will display the approximate RA and Dec under the cursor. To do this XEphem makes an assumption about the scale and orientation of the image and defines the center of the image as the position of the sun computed at the current XEphem time. However, we have found SOHO images are not always oriented the same way and we are not aware of a means to know the orientation programmatically so beware. The Carrington Rotation Number is shown in the lower right, also as of the current XEphem time. If XEphem time differs from when the SOHO image was acquired the coordinates will still be correct but of course the solar features shown in the image will not be correct.

Note that the coordinates do not take account of the different perspective from the SOHO spacecraft. SOHO does not wander far from the Sun-Earth line so images of the sun itself do not suffer much but this effect is quite pronounced for Large Angle and Spectrometric Coronagraph images where the coordinates of background objects may be off by a degree or more. Again, beware and check all coordinates independently for important work.

4.2.2 Sun Control menu

Download latest

Clicking this entry will use your Internet connection to download the latest image from SOHO. The type and size of the downloaded image are determined by the current selections in the Type and Size menus.

Save downloaded image

This button is active only if the currently displayed image was downloaded from the net and has not yet been saved. Clicking this button will save the downloaded SOHO image currently being displayed to the Private XEphem directory in .gif format. The name of the file always begins with SOHO and includes the size, date, time and code name of the data product. For example, the following file name:

```
SOHO_512_20030802_0100_eit_171.gif
```

indicates the file is 512x512, was acquired 2003 Aug 02 at 01:00 UTC and is from the 171Å channel of the Extreme ultraviolet Imaging Telescope.

Filter Files by Type
Filter Files by Size

These options control whether the files presented by the Files menu will be filtered by the current setting of the Type menu or the Size menu, respectively. If a filter is not selected then all files found will be listed.

Print...

This selection allows printing the current SOHO view or saving it to a file. See Printing.

User annotation...

This selection brings up a window which allows text and lines to be drawn over the SOHO image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Sun view to a movie loop.

4.2.3 Sun Files menu

This menu lists each of the SOHO image files currently found in either the Private or Shared directories. Depending on the Filter settings in the Control menu it will list all images or just those that match the current setting of the Type or Size menus. Selecting a file from the list will display it in this window.

4.2.4 Sun Type menu

This menu lists each of the eight data products provided by SOHO, one of which may be selected at a time. The type selected here will be used when Downloading a file from the Control menu, and may also limit the scope of files listed by the Files menu if the Filter option is On in the Control menu. Follows is a brief summary of the data product referenced by each menu entry.

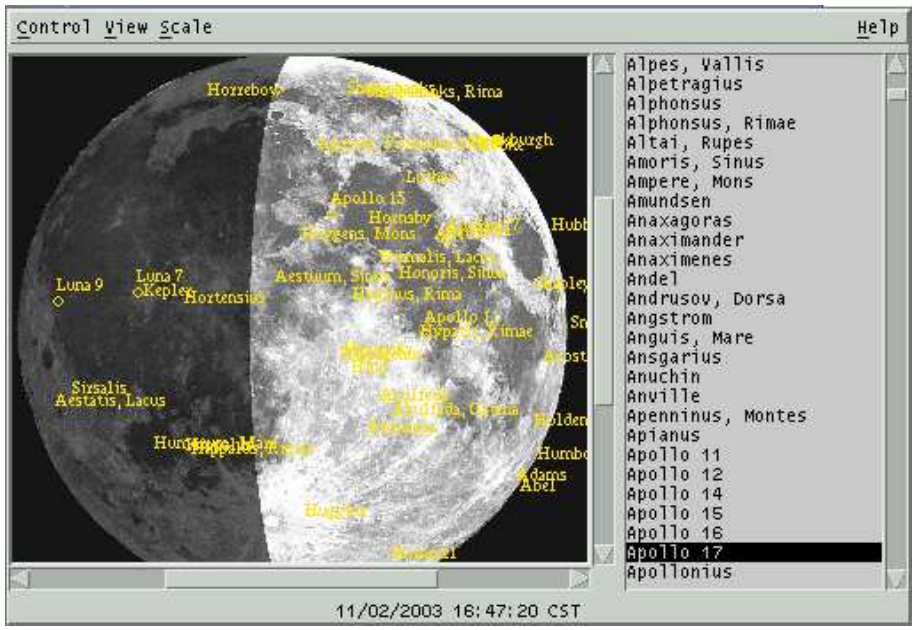
Menu Entry	Instrument	Notes

EIT 171	Extreme ultraviolet Imaging Telescope	Fe IX/X 171 Å, rendered blue
EIT 195		Fe XII 195 Å, rendered green
EIT 284		Fe XV 284 Å, rendered yellow
EIT 304		He II 304 Å, rendered orange
MDI Continuum	Michelson Doppler Imager	Visible Sun spots
MDI Magnetogram		Magnetic Sun spots
LASCO C2	Large Angle and Spectrometric Coronagraph	Corona to 6 solar radii
LASCO C3		Corona to 3 solar radii

4.2.5 Sun Size menu

This menu lists each of the three file sizes of images provided by SOHO, one of which may be selected at a time. The size selected here will be used when Downloading a file from the Control menu.

4.3 Moon



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 lunar coordinate directions.

The scolling list on the right lists all features in the data base. Clicking on a name will toggle its label on the map. The labels are positioned so the center of the feature is at the lower left corner of the label string. If the label is being turned on then the Labels View option is also turned on if it is off. Double-clicking will display the set of Lunar Orbiter images that include the feature.

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.

4.3.1 Moon mouse

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.

Right button

Activating the right mouse button while over the lunar image will display a popup menu. It lists the name of the feature nearest to the cursor, the type, lunar coordinates and the altitude of the sun as seen from that feature at the current XEphem time. A toggle button **Label** turns on or off a label on the map. A pushbutton **Set info table** loads the feature into the More info window and will display window if it is not already up. If the Lunar Orbiter database has been loaded, then a pushbutton **Lunar Orbiter image** displays the image in which this feature lies, and also turns on the feature's label on the main map for handy reference.

Activating the right mouse button while not over the lunar image but near a sky background object will pop up a menu containing the name and magnitude of the object. There will also be a button **Add to favorites** to assign the object to your Favorites.

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 first, 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.

4.3.2 Moon Control menu

Print...

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

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Moon view to a movie loop.

Field Stars...

This selection activates the Field Star setup window. See Field stars.

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 button 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.

Forget labels

This button forgets the labels that have been added either via the popup or the list to the right. Note this is different than turning off labels in the View menu, which only temporarily turns of the labels but does not forget.

Close

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

4.3.3 Moon View 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.

Labels

This sets whether additional (non-spacecraft) Lunar features may be labeled on the image. Exactly which ones are labeled is controlled from the scrolled list down the right or with the popup menu activated by the right mouse button. Note that turning labels off with this button does not forget which features are labeled, it only turns them off. To actually forget the labels, use the Undo labels button in the Control menu.

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 automatically retrieve field stars if the moon position changes on the sky

{Pen}Umbra

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

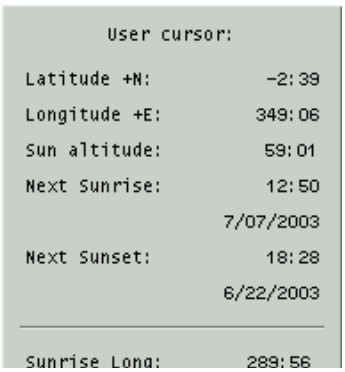
Flip T/B
Flip L/R

These set whether the image is flipped vertically or horizontally, respectively.

Grid

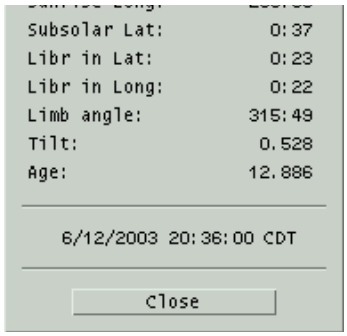
This sets whether a coordinate grid is drawn over the image. Each line is spaced at an interval of 15 degrees. Also, the current subearth location is marked with an X; the subsolar point is marked with a small open circle; and the anti-subsolar point is marked with a small filled circle.

4.3.3.1 More info...



This brings up a separate window with additional information. 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 Preferences 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.

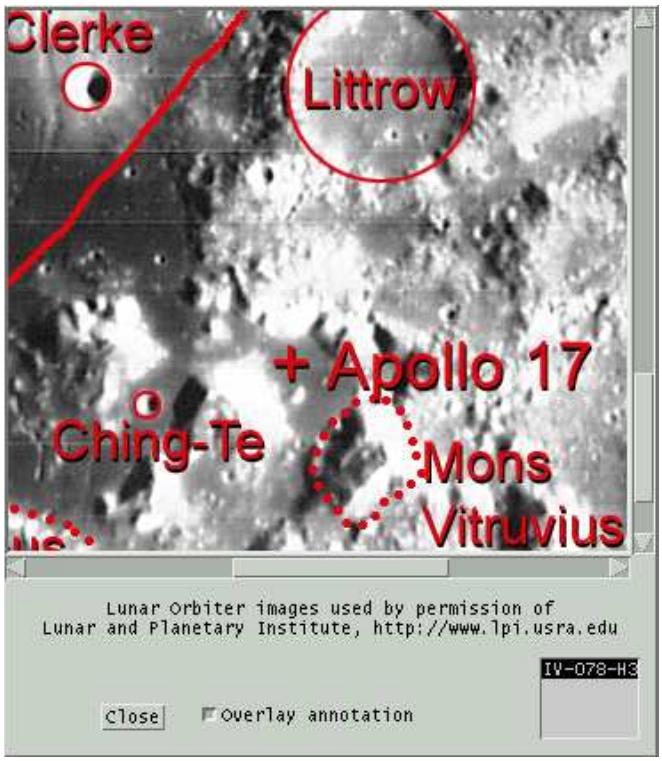
Any of the values in the lower portion may be plotted, listed or used in a solver algorithm. The values are always current when used in this way, even if the main Moon view is closed. For faster looping, close the main Moon display to prevent it from being redrawn each time.

4.3.4 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.

4.3.5 Lunar Orbiter IV

XEphem optionally supports displaying images taken by Lunar Orbiter IV in 1967. These images and the features database are used by permission of the Lunar and Planetary Institute.



Lunar Orbiter images are located in the `lo` directory within the Shared directory. When these images are installed they are accessible from the Moon view in two ways. One is to double-click an entry in the features list down the right of the Moon view window. The other is to use the Lunar Orbiter images button in the popup over the image in the main Moon window. These functions are automatically disabled if XEphem can not fund the images on startup.

The LO images are displayed in their own window. The images are large so panning controls are available on the bottom and right edges. The annotation overlay may be toggled on and off with the given toggle button. A scrolled list in the lower right corner allows choosing one from among all the LO images which contain the current feature.

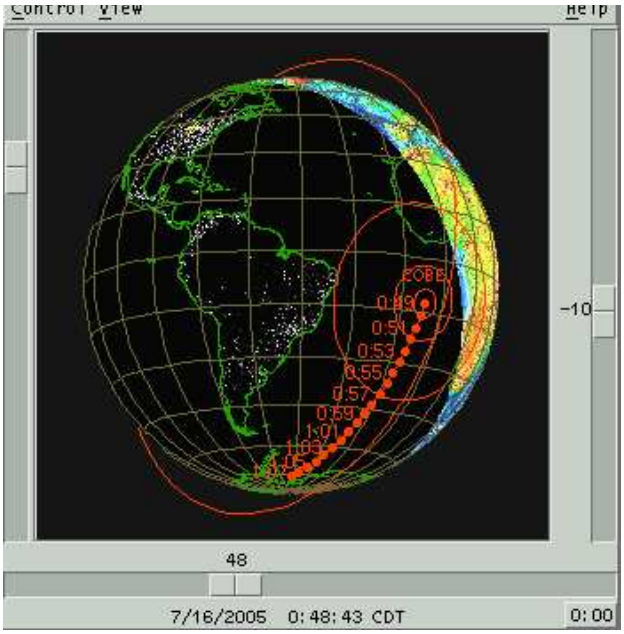
The LO images are not perfectly aligned NSEW, some are canted as much as 30 degrees from vertical. The images are shown exactly as they were taken. No attempt is made to register the images with the main XEphem moon view, nor to perform flipping or scaling. The ability to click to see the next adjacent image would have been nice but certain technical difficulties made the results unsatisfactory and was left out.

The image scale is approximately 300m/pixel.

4.4 Earth

This view displays a view of the Earth with either schematic continent outlines or a real color image. The night

side may be dark or include nightside lights. The projection may be spherical or cylindrical "Mission Control" style. The controls available from the menu bar across the top control the view, the display of additional information and the ability to overlay the ground positions of all Favorite objects. The scales along the bottom and right edges display, and may be used to control, the center longitude and latitude location. The button in the lower right corner sets the latitude to exactly zero. The scale along the left edge sets the zoom.



Any or all of the current Favorites may be displayed on the map. Objects with defined date ranges are only shown when they are valid. 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.

4.4.1 Earth mouse

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 sliding the scale at the bottom; moving it up and down is like sliding the scale at the right. This provides a simple method to pan the display.

Right button

If the right mouse button is clicked while over the Earth, a popup menu appears with information related to the location under the cursor.

If the location is near a Site, information is presented with respect to the exact location of that site.

If the location is not near a Site, the information 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 either on the surface or in orbit, the information is with respect to the location of that object at the time of the trail mark.

There will also be a button labeled Point that will center the orientation on the cursor location.

4.4.2 Earth Control menu

Print...

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

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Earth view to a movie loop.

Objects...

This brings up a table for controlling how each current Favorite object is displayed.

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.

4.4.3 Earth View menu

Cylindrical graphic
Cylindrical image

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. 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.

Spherical graphic
Spherical image

Displays the Earth as it would really appear from space. The primary advantage is the sense of reality and lack of distortion. Either projection may be shown using a simple graphical technique which draws only the outlines of the major land features, or using a full color image, courtesy NASA's project Blue Marble. The former is fast, the latter looks much better. The spherical projection resizes to become a square by setting the width equal to the height.

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 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 turned on. 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 or either Image projection, the map is darkened where the Sun is currently down, and only continent outlines are shown.

Main marker

This toggles whether a small marker is drawn at the location currently showing in the XEphem Main window.

Nightside lights

This toggles whether the dark side of the view will include lights visible from space. This option is only available using either of the Image methods (not Graphics). Image is courtesy NASA.

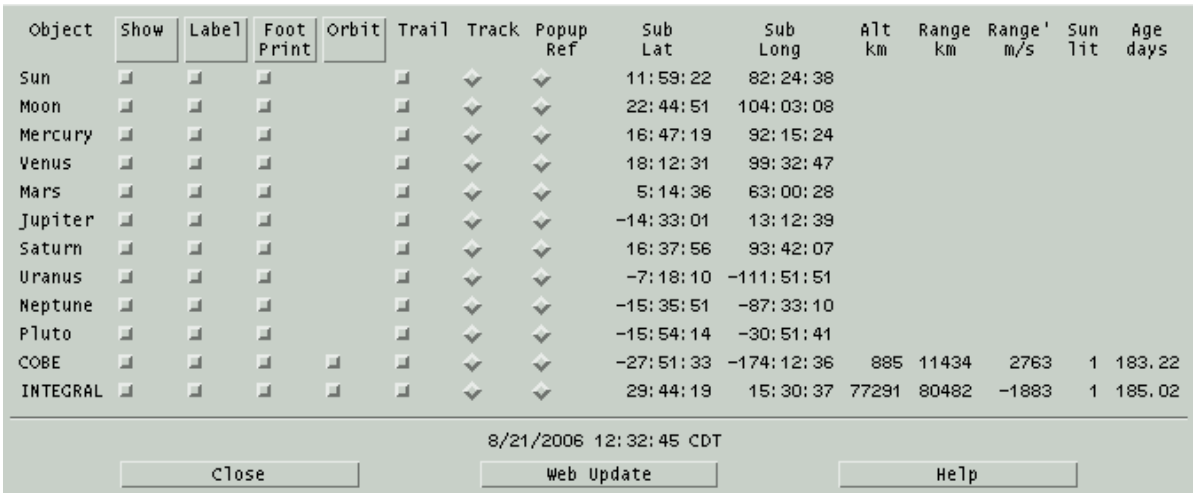
Live dragging:

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.

Inertial frame:

When On, the display point of view remains fixed in space; when Off, it remains over a fixed location on the earth's surface.

4.4.3.1 Objects dialog



This dialog shows one row for each active Favorite. The columns are as follows:

Object
: This is the name of the Object.

Show
: Determines whether the object is shown on the Earth map at all. If On, the object subearth location is shown as a cross × surrounded by the loci of points at which the object is 60, 30 and 0 (on the horizon) degrees altitude. Clicking on the title toggles the individual buttons for all objects.

Label
: Determines whether the name of the object is drawn somewhat above its cross. Clicking on the title toggles the individual buttons for all objects.

Foot Print
: The footprint is a set of three contours indicating the locations from which the object appears at 0, 30 and 60 degrees above the horizon. This toggle chooses whether to show these contours or just the sub-earth postion. Clicking on the title toggles the individual buttons for all objects.

Orbit
: Determines whether to draw the orbit of an earth satellite. The orbit is drawn starting from the current location of the satellite as seen from space, irrespective of subsequent earth rotation. Clicking on the title toggles the individual buttons for all objects.

Trail
: Brings up a window to define the time duration and labeling of the ground track of the object. See Trails After a trail has been created, this toggle then allows it to be turned off and on without deleting it. The trail really is deleted if it is Off and an Update occurs. After being deleted, this toggle again brings up the window to define a trail. Note that the trail may be redefined as many times as desired directly from the Trail window, it does not need to be deleted each time.

Track
: At most one button in this column may be On. The object for which Tracking is on will remain centered in the view each time Update occurs.

Popup ref
: At most one button in this column may be On. When right-clicking on the map with one of these buttons on, the bearing and altitude from that location to this object are displayed.

The remaining columns are informational only but be used for plotted, listed or used in a solver algorithm. Sub lat and long are displayed for all types of object, the others are displayed for Earth satellites only.

Sub lat
Sub long
: These columns display the latitude and longitude at which the given object appears exactly overhead.

Alt
: This is the distance from the mean geode to the satellite.

Range
: This is the line of site distance from the current Main location to the satellite.

Range'

This is the rate of change of Range. It is useful for computing the doppler shift of a signal arriving from the satellite.

Sun lit

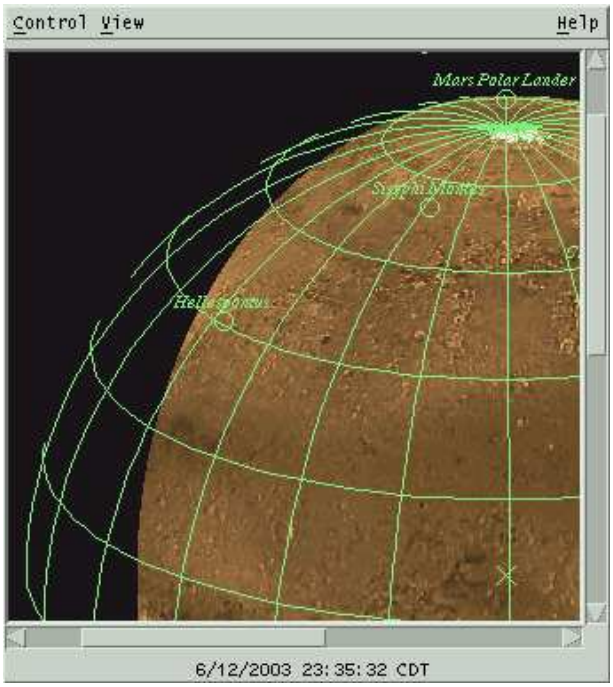
This column is a 1 or 0 depending on whether the satellite is in sun light. Note this is *not* whether the subearth point is in sun light.

Age Days

This is the age, in days, of the elements used to compute the satellite orbit. Drag is included but elements older than a few days will already show errors. Use the handy Web Update button at the bottom to download the latest elements.

4.5 Mars

This window displays an image of Mars as it currently appears from Earth center. The orientation is always parallel to the Martian rotation axis. The NSEW markings are directions on the celestial sphere.



4.5.1 Mars mouse

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. Repointing 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, just the cursor location is shown.

4.5.2 Mars Control menu

Print...

This selection allows printing the current Mars view or saving it as a Postscript file. See Printing.

User annotation

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation

Add to movie...

This selection brings up a window to allow adding the current Mars view to a movie loop.

Close

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

4.5.3 Mars View menu

Half size

This sets whether the map is drawn at full available resolution or at one half resolution.

Flip T/B
Flip L/R

This sets whether the image is flipped vertically or horizontally, respectively.

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 rotated, an X marks the center of the image, that is, the subearth location.

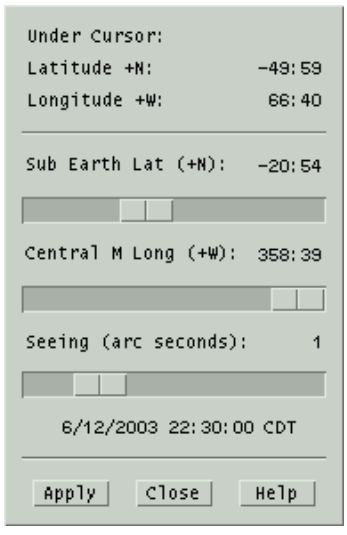
4.5.3.1 Features...

This window displays categories of surface features and a scrolled list of individual features sorted by name. The features that are selected in the scrolled list are the ones drawn on the map. Craters and single Mountains are drawn with a circle to scale, landing sites with a small circle and other categories are just labeled by name.

Click an entry in the scrolled list to turn it on or off individually. Or select features by category by clicking the toggle buttons down the left and possibly **Toggle, All** and **None** as convenient, then clicking **Apply**. **Ok** does the same but also closes this window.

As a special case if everything in the scrolled list is unselected and one feature is selected, the map will be rotated to place the selected feature in the center. This is handy for locating a feature by name. Note that all features may be deselected easily by clicking **None** then **Apply**.

4.5.3.2 More info...



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.

Sub Earth Lat shows the Martian latitude which currently faces the Earth. The value is computed each time an Update is performed from the Main Menu. The scale below allows you to set another value if desired as described below.

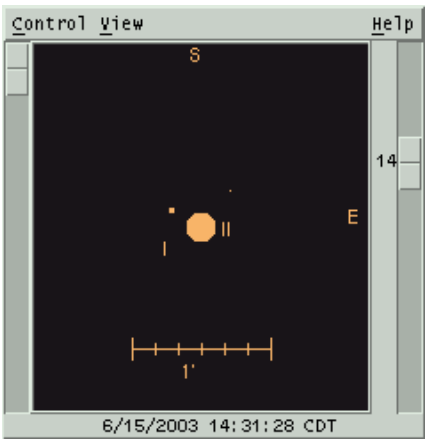
Central M Long shows the central meridian longitude, or simply Martian longitude, which currently faces the Earth. The value is computed each time an Update is performed from the Main Menu. The scale below allows you to set another value if desired as described below.

Seeing sets the size of your local atmospheric seeing disk in arc seconds. The image will be blurred to simulate the resolution under this condition.

For browsing purposes, the scale 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 plotted, listed or used in a solver algorithm. 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.

4.5.3.3 Moon view...



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. The values range from 20 at the top and 0 at the bottom. Objects dimmer than the value specified are not shown, except that Mars is always 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.

Mars Moons mouse

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.

Mars Moons Control menu

Print...

This selection allows you to print the current view. See Print.

User annotation...

This selection lets you place text and lines on the current view. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Martian moon view to a movie loop.

Field Stars...

This selection activates the Field Star setup window. See Field stars.

Telescope GoTo

This option, when available, causes the location of Mars to be sent to a telescope control process. This mechanism is the same as that provided by the Telescope facility within the Sky view. See Telescope

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.

Mars Moons 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 stars 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

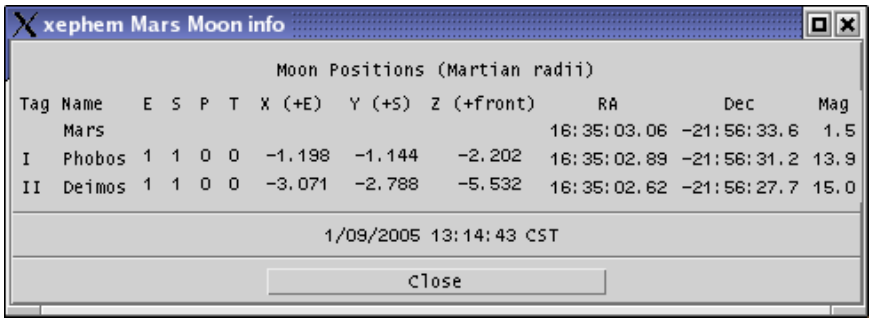
Whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B
Flip L/R

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

More info...

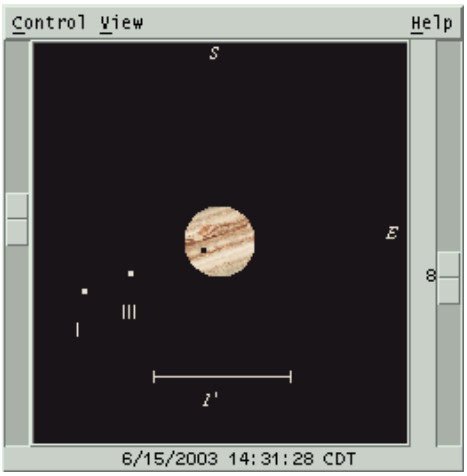
This button brings up a separate window which contains quantitative information about Mars's moons. All values may be used in plotting,listing and solving.



The E and S columns are 1 if the moon is geometrically visible from the Earth and Sun, respectively. The P column is 1 if the shadow of the moon currently falls on the planet. The T column is 1 if the moon is currently transiting the planet. Otherwise the columns are 0.

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 equatorial plane. The next two columns give the RA and Dec location of the moons in the current epoch (as specified on the Main window).

4.6 Jupiter



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 77 degrees, where it was in late May of 2002. This may be changed interactively in the More Info window.

4.6.1 Jupiter mouse

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.

4.6.2 Jupiter Control menu

Print...

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

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Jupiter moon view to a movie loop.

Field Stars...

This selection activates the Field Star setup window. See Field stars.

Telescope GoTo

This option, when available, causes the location of Jupiter to be sent to a telescope control process. This mechanism is the same as that provided by the Telescope facility within the Sky view. See Telescope

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.

4.6.3 Jupiter View menu

Top view

Selects whether to display another window above the front view with a vantage point over the pole. This window will try to remain aligned above the main Jupiter front 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 stars 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

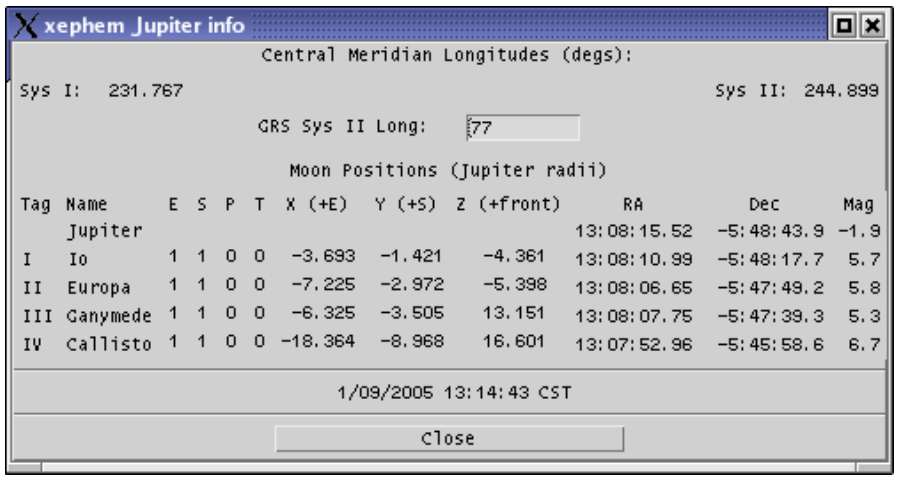
Selects whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B
Flip L/R

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

4.6.3.1 More info...

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.

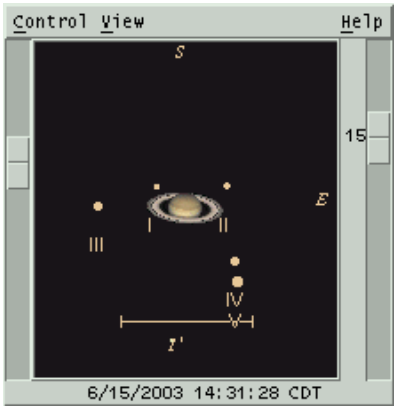


The E and S columns are 1 if the moon is geometrically visible from the Earth and Sun, respectively. The P column is 1 if the shadow of the moon currently falls on the planet. The T column is 1 if the moon is currently transiting the planet. Otherwise the columns are 0.

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.

4.7 Saturn



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.

4.7.1 Saturn mouse

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.

4.7.2 Saturn Control menu

Print...

This selection allows printing the current Saturn view or saving it to a file. See Printing.

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Saturn moon view to a movie loop.

Field Stars...

This selection activates the Field Star setup window. See Field stars.

Telescope GoTo

This option, when available, causes the location of Saturn to be sent to a telescope control process. This mechanism is the same as that provided by the Telescope facility within the Sky view. See Telescope

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.

4.7.3 Saturn 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 front 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 stars 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.

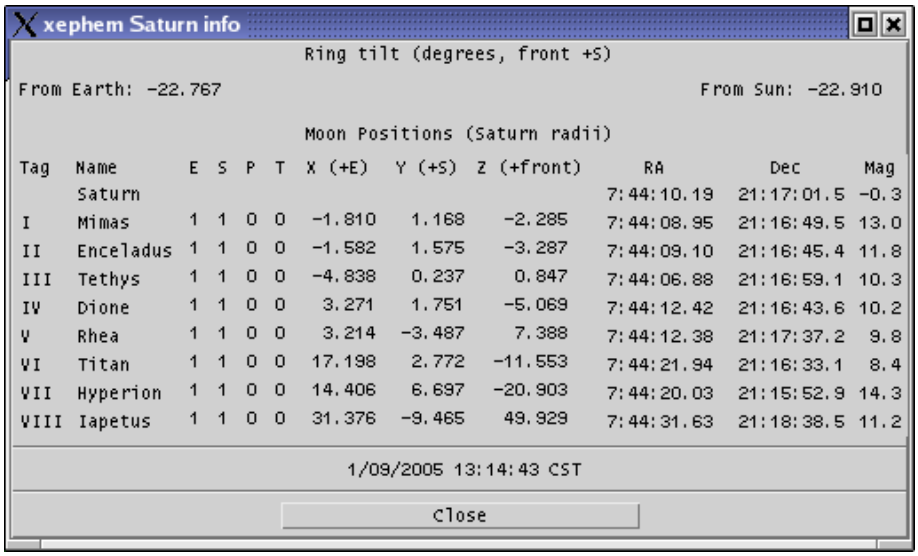
Tags

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.

4.7.3.1 More info...



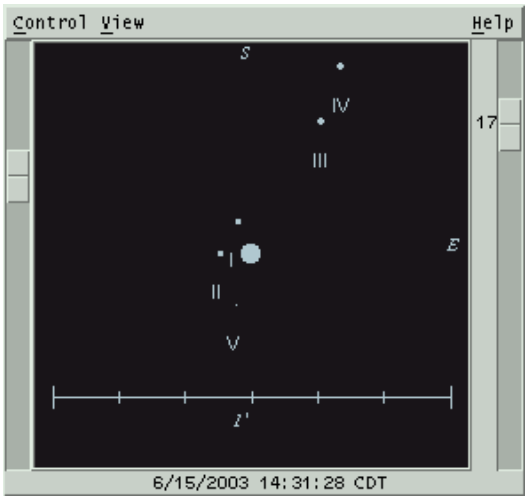
This button brings up a separate window which contains quantitative information about Saturn's moons and its rings. All values may be used in plotting,listing and solving.

The E and S columns are 1 if the moon is geometrically visible from the Earth and Sun, respectively. The P column is 1 if the shadow of the moon currently falls on the planet. The T column is 1 if the moon is currently transiting the planet. Otherwise the columns are 0.

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).

4.8 Uranus



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.

4.8.1 Uranus mouse

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.

4.8.2 Uranus Control menu

Print...

This selection allows printing the current Uranus view or saving it to a file. See Print.

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Uranus moon view to a movie loop.

Field Stars...

This selection activates the Field Star setup window. See Field stars.

Telescope GoTo

This option, when available, causes the location of Uranus to be sent to a telescope control process. This mechanism is the same as that provided by the Telescope facility within the Sky view. See Telescope

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 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 Saturn display, and the additional information window if present, from the screen.

4.8.3 Uranus 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 stars 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

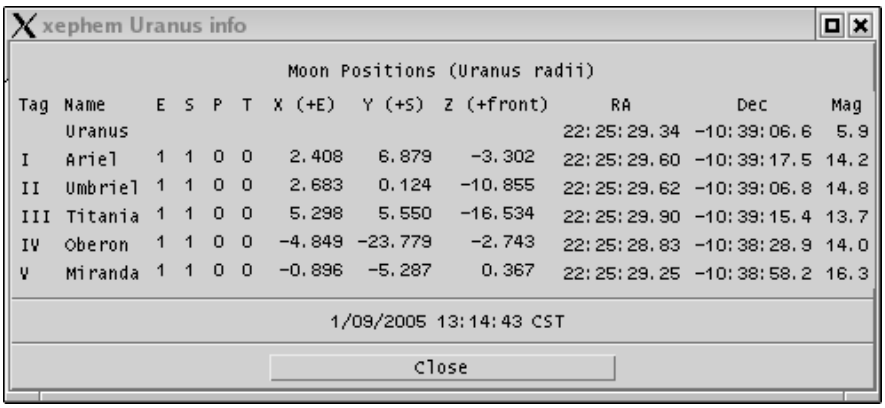
Selects whether to show the Roman numeral designation beneath each moon and a 1 arc-minute scale calibration line.

Flip T/B
Flip L/R

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

4.8.3.1 More info...

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



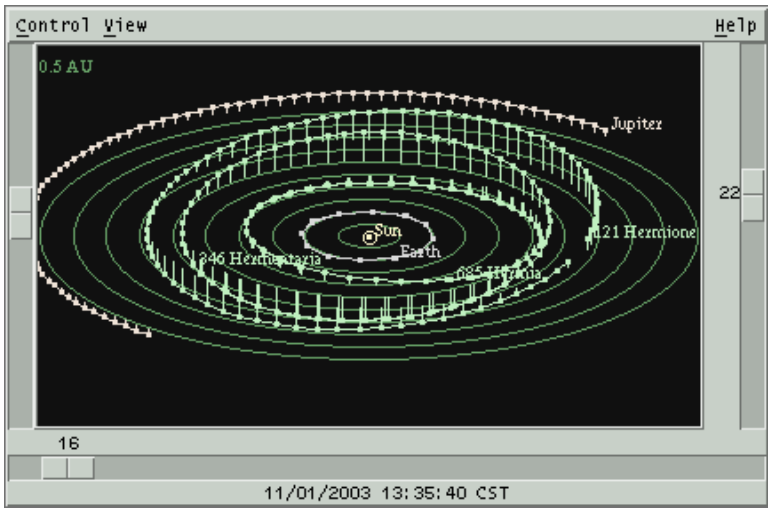
The E and S columns are 1 if the moon is geometrically visible from the Earth and Sun, respectively. The P column is 1 if the shadow of the moon currently falls on the planet. The T column is 1 if the moon is currently transiting the planet. Otherwise the columns are 0.

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 window).

4.9 Solar System

This is a graphical representation of the solar system. The Sun is always at the center of the screen, marked with a small circle. The set of objects displayed are the ones from the Favorites list that are solar system objects. Objects with defined date ranges are only shown at valid times.



4.9.1 Solar System 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. You can also control this with the keypad + and - keys. Using the key alone moves by 2% little, with Shift moves by 10%.

The horizontal scale across the **bottom** of 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 vector pointing straight at you. You can also control this with the keypad Left and Right arrow keys. Using the key alone moves by 2%, with Shift moves 10%.

The vertical scale on the **right** controls the heliocentric latitude, your angle above or below the ecliptic plane. You can also control this with the keypad Up and Down arrow keys. Using the key alone moves by 2%, with Shift moves 10%.

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.

4.9.2 Solar System mouse

Right button

Clicking the right mouse button near an object will pop up a menu with additional information. 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.

Persistent Label toggles whether the label for the object is displayed regardless of whether the `View » Labels` option is activated.

4.9.3 Solar System Control menu

Print...

This selection allows printing the current Solar System view or saving it to a file. See Printing.

Favorites...

The Solar System view displays the current set of Favorites that are in the solar system.

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation

Add to movie...

This selection brings up a window to allow adding the current Solar System view to a movie loop.

Create Trails...

This button will bring up a window to set up making a trail for each 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 Favorites are trailed. The other solar system objects, if any, are always shown in their current positions. See Trails.

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 response depends on the speed of the computer, display and data bandwidth. If the system is fast enough, turning this on can produce dramatic depth clues 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, legs are turned on and the Ecliptic plane circles are turned off. 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 when viewing from near the poles it just moves everything equally.

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. You can also control this scale with the keypad slash (/) and star (*) keys.

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.

4.9.4 Solar System View menu

Trails

This toggles whether trails, if currently defined, are displayed. The trails may be turned on and off as desired without loss but the trails are permanently discarded when the next Update from the Main window occurs.

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.

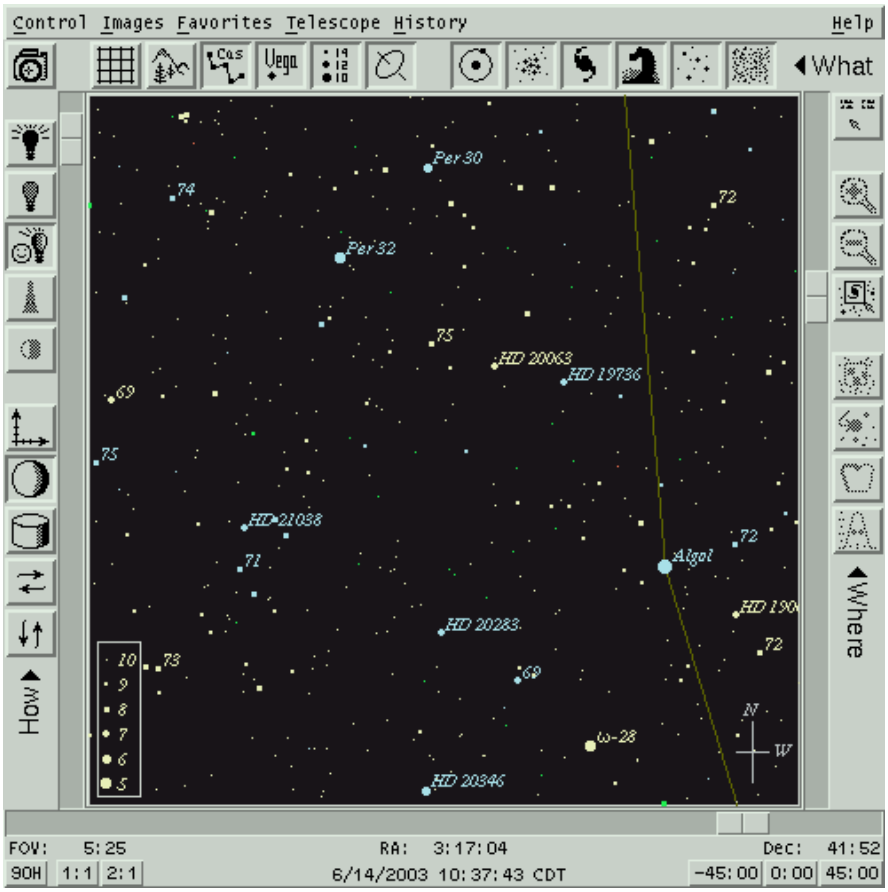
Legs

This toggle button controls whether a line is drawn from each object down to the ecliptic. This aids in visualizing the 3D location of the objects.

DB too

This allows showing all objects currently loaded into memory that lie within the solar system, in addition to the Favorites.

5.0 Sky View



This view 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. Objects with defined date ranges are only shown at valid times. 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.

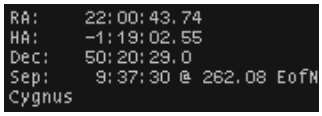
Note that while looping with Pause set to 0 the Sky View is not updated (although all quantitative information is always updated internally each step). This is to permit creating plots and using other XEphem features that use many time increments to run much more quickly if the Sky View is unmanaged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

If the object is an Earth satellite, its label will be surrounded in parentheses if it eclipsed at that location.

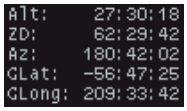
5.1 Sky View mouse

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.

No buttons:



Generally nothing happens when the mouse is over the Sky View and no buttons are being pressed. However, if the Corner Coordinates toolbar button (upper right) is On, 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 depressed. These data include:

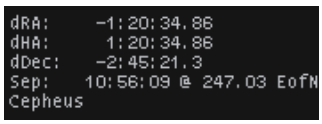


- **In the Upper left corner:**
  - RA, Dec and Hour angle equatorial coordinates;
  - the great-circle distance and bearing between the current position and the point at which the left button was last clicked;
  - constellation name;
  - if displaying FITS image, raw image pixel coordinates. *N.B. FITS coords = XEphem coords + 1*
- **In the Upper right corner:**
  - Alt, Az and Zenith horizon coordinates;
  - Galactic latitude and longitude

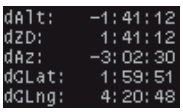
The coordinates are derived directly from the screen location and know nothing of the displayed objects. Thus, they neglect parallax (i.e., assume everything is at infinity).

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 Region of Interest toolbar button is On and the left mouse button is pressed, then the information in the upper left and right corners changes 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. With the ROI toolbar button On, 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 current size, position, and ROI are saved and the Sky View is changed to expand the new area. The Zoom Back tool bar button 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.

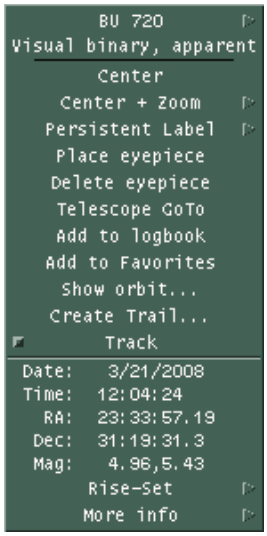
The other use for the ROI is available only when an image is being display. Basic statistics are computed for the pixels that lie within the ROI box. Also only while an image is displayed, the left mouse button may be used to position a Magnifying glass; graph the pixels along an arbitrary cross sectional 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. See Image analysis.

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.

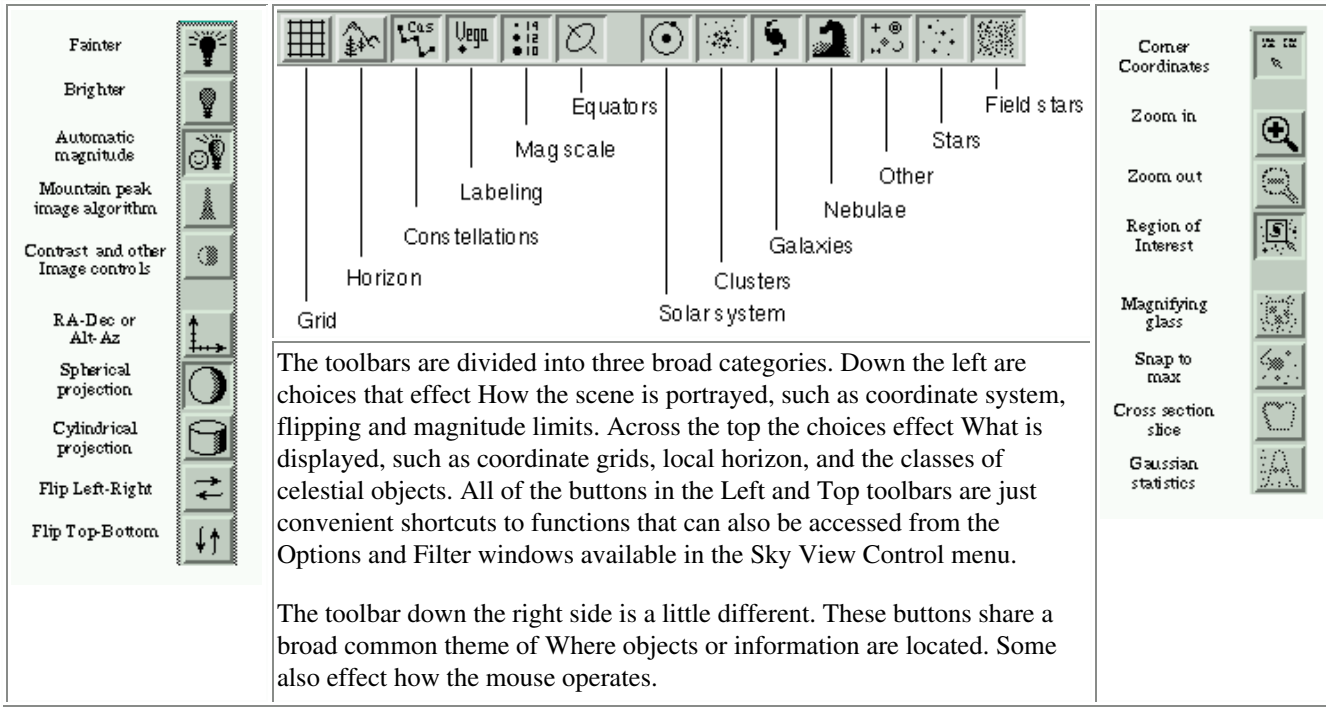
The popup contains information and controls germane to the exact position of the cursor when the button was clicked. The entries in the popup menu vary depending on whether the cursor was near an object or over empty sky. If the cursor is near a object, data is shown which are exactly the same as that which is available in the Data Table window. If a trailed object is selected, the data applies 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. Remember, only the ones relevant to the current situation and toolbar choices will appear.

- **Name** will show the name of the object. If alternate names are available they will be displayed in a pullright cascade menu.
- **Type** will display a brief description of the type of object.
- **Center** will change the Sky View pointing direction to place the given object (or location) at the center of the field of view.
- **Center + Zoom »** is like Center but will also zoom in or out the amount selected in the pullright cascade menu.
- **Persistent Label » on Left on Right** 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).
- **Place eyepiece** will cause an eyepiece symbol to be drawn centered under the mouse location. The eyepiece shape and size are defined in the Eyepiece Setup window, available at `Control » Eyepieces`. Both the RA-Dec and Alt-Az of the location are saved and the one matching the Display mode is used when the eyepiece is drawn on the Sky View. In this way eyepieces can be fixed in either coordinate system. See Eyepieces.
- **Delete eyepiece** will delete the closest eyepiece covering this mouse location. 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.
- **Telescope GoTo** will cause the coordinates of the cursor to be sent to the INDI 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 Telescope.

- **Add to logbook** will copy pertinent position and descriptive information about the current object to a new entry in the Observers logbook. This selection only appears if the logbook tool window is currently open.
- **New Photom ref** 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.
- **Show orbit...** is only present if the selected object is a Binary system. It brings up a window showing the orbit of the secondary around the primary and an ephemeris for one revolution. See Binary Star Map for more information.
- **Add to Favorites** will add this object to the Favorites list.
- **Create Trail...** will bring up a window from which a trail may be easily 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. See Trails.
- **Track** 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 `Control » Tracking` toggle button for more details.
- **Trail** 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.

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

The toolbar down the right side is a little different. These buttons share a broad common theme of Where objects or information are located. Some also effect how the mouse operates.

5.3 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 offer 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 Width:Height aspect ratios. When an image is loaded, an additional button appears labeled Image. Clicking this will resize the window to match the aspect ratio of the image. The FOV scale may also be changed using the keypad + and - keys. Using the key alone moves by 2%, with Shift moves 10%.

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. The Alt/Dec scale may also be changed using the keypad Up and Down arrow keys (make sure your NumLock is off). Using the key alone moves by 2%, with Shift moves 10%.

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. The Az/RA scale may also be changed using the keypad Left and Right arrow keys (make sure your NumLock is off). Using the key alone moves by 2%, with Shift moves 10%.

5.4 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 Trails Setup window to select the interval, number of steps, formatting details and which steps you would like annotated. The trail setup window 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 small 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 window 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 Filter window, *i.e.*, trailed objects are always shown.

Note that in Alt-Az mode, each trailed location is positioned on the display according to the sky at the current moment. But 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 window.

5.5 Sky View Control menu

This is a summary of the Sky View Control menu. Details follow.

Options...

This brings up a window with several choices effecting the way the scene is drawn. See Options.

Filter...

This allows selecting the types and magnitude ranges of objects to display. See Filter.

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. See Printing.

List...

This brings up a window that allows saving the objects currently displayed in the Sky View to a file. See List.

Horizon...

This activates the Horizon setup window where you can define new or load existing horizon profiles. To actually display the Horizon profile, turn on the toggle under Option. See Horizon.

Field Stars...

This activates the Field Star setup window. To display Field Stars, turn on the toggle under Options. See Field stars.

Favorites ...

This activates the Favorites setup window. See Favorites.

Eyepieces...

This brings up a window which allows you to specify the shape, size, rotation and style of the next eyepiece to be created. See Eyepieces. Whether eyepieces are shown at all is controlled by the `Control » Options » Eyepieces` option; see Options.

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. The coordinates may be set from or used to repoint the Sky View. See Coordinate converter.

User annotation...

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

Add to movie...

This selection brings up a window to allow adding the current Sky view to a movie loop.

Tracking

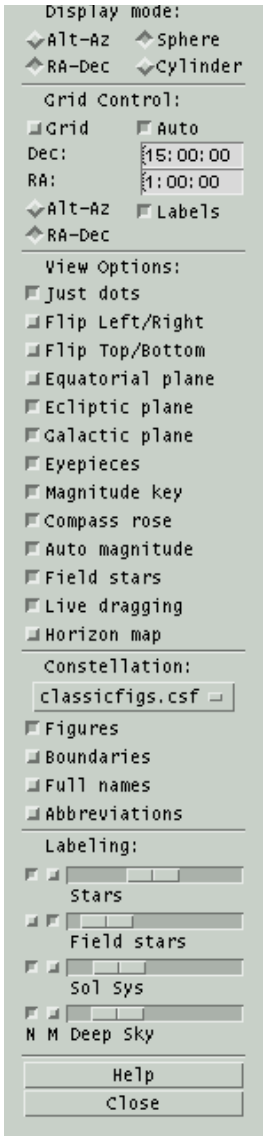
Tracking in this context refers to whether the pointing direction of the Sky View will automatically be changed each time an Update occurs from the Main window such that the tracked object will remain centered on the display. The object to be tracked is selected by using the **Track** option in its popup menu, as described elsewhere. 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 × 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.

5.5.1 Options

5.5.1.1 Display mode:



Alt-Az
RA-Dec

This pair selects whether the display coordinate system is Altitude-Azimuth or Right Ascension-Declination. 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 pair selects whether the display is projected onto a sphere or 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.

5.5.1.2 Grid Control:

This group of controls allows you to specify the details of an overlay coordinate grid.

Grid

Toggles the grid on or off.

Auto

If on, 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
RA-Dec

This pair selects in which coordinate system the grid will be drawn.

Label

Selects whether the grid will be labeled.

5.5.1.3 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.

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 toggles whether a red 3:6 dashed line is shown along the Earth's equator projected onto the celestial sphere. The North and South celestial poles are marked and labeled as NCP and SCP, respectively.

Ecliptic plane

This toggles 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 Vernal and Autumnal equinoxes and Summer and Winter solstice locations are marked and labeled as VEq, AEq, SS and WS respectively. The North and South eclipic poles are marked and labeled as NEP and SEP, respectively.

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 toggles whether a red 1:4 dotted line is shown along the galactic equator. The North and South galactic poles are marked and labeled as NGP and SGP, respecively. The galactic center is marked and labeled as GC. The outline of the Milky Way boundary is also shown.

Eyepieces

This toggles 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. 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.

Compass rose

This toggles whether two symbols to indicate the cardinal directions at the center of the Sky View in each Display mode are drawn in the lower right corner. The symbol on the right always shows the current mode, the symbol to its left the opposite mode. The one labeled with **Z** and **R** indicates the local horizontal directions toward the Zenith and toward the Right; the one labeled with **N** and **W** indicates equatorial North and West. The symbols are not drawn near their respective poles.

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. Note that initial resource values for faintest magnitudes and dot step size will not be honored unless the initial resource value for automag is also off.

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.

Live dragging

This toggles 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. What works best for you 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 toggles whether to display the local horizon profile on the Sky View and whether objects below the horizon are drawn. The profile linearly interpolated between points in the defining file. See Horizon.

5.5.1.4 Constellation:

File name

This drop-down selection allows you to select the file that defines constellation figures. The files supplied with XEphem are HAReyfigs.csf and classicfigs.csf to define the figures defined by H. A. Rey or the classic definitions, respectively. The files shown for possible selection are those files ending with the .csf suffix in the Shared and Private directories.

The definition file must contain exactly one figure for each of the 89 constellations. Leading white space, blank lines and lines beginning with # are ignored. Each figure definition begins with a line containing just its name followed by one or more lines of the form:
drawcode ra dec [comment]
where
drawcode is a numeric value indicating a drawing instruction as follows:
0 move to ra dec
1 draw solid line to ra dec
2 draw dashed line to ra dec
ra is decimal hours or sexigesimal h:m:s
dec is decimal degrees or sexigesimal d:m:s
the remainder of the line is ignored and may be any comments, typical is the name of a star being drawn to.

Figures
Boundaries

This pair controls whether to show constellation figures and/or constellation boundaries.

Full Names
Abbreviations

This radio pair controls whether and how constellation names are shown. The choices are full names, their 3-letter abbreviations or neither.

5.5.1.5 Labeling:

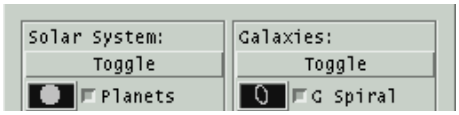
This portion controls labeling options. The sliders select how many of the brightest objects to label in each of four categories. The count ranges from 0 on the left to All on the right.

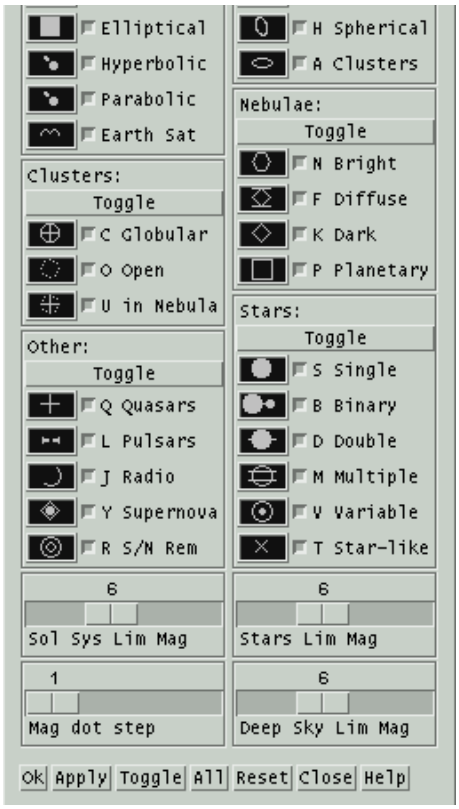
The label itself may consist of the Name or Magnitude or both, depending on the state of the two buttons in the columns marked N and M to the left of each scale. If Names and Magnitudes are both turned on then the magnitude is drawn to the right of the name surrounded by parentheses. Magnitudes are always drawn to the nearest 1/10 with the decimal point removed.

Trailed entries and objects marked for Persistent Label do not contribute towards the brightest count.

5.5.2 Filter

This window lists all classes of objects supported by XEphem. Using the Filter window, you 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 `Control » Options » Just dots` is selected. Note that the symbol used to draw an Elliptical object in the Sky View is the same as that for objects of type Hyperbolic and Parabolic if the name of the object begins with "C/" (presumed to denote a comet).

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 diameter of the symbol drawn in the Sky View 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.

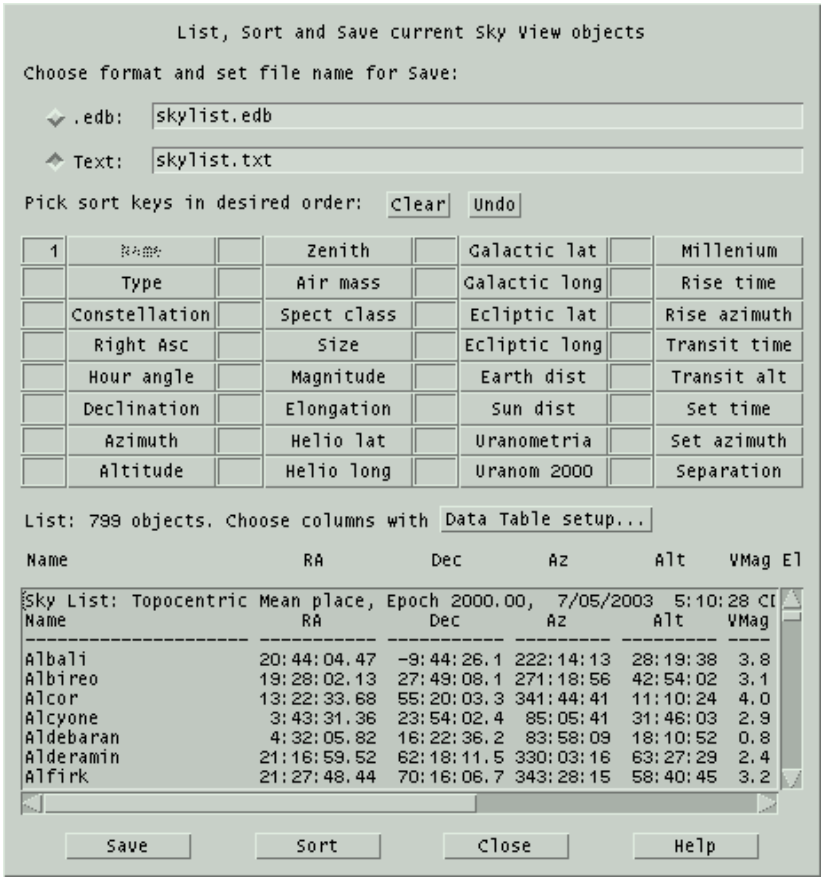
The fourth scale in the lower left selects the number of magnitudes binned in each dot size. Values larger than 1 are helpful for showing very large ranges of magnitudes.

Several push buttons appear across the bottom of the Filter window which have the usual 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** swaps which filters and Or and Off. **Reset** will return the state of all Filter controls to their state when this window first appeared or the most recent Apply.

5.5.3 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. See Printing.

5.5.4 List



This window lists, sorts and writes the objects currently displayed in the Sky View to a file. Basing the list on the Sky View allows the selection criteria to use the full 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.

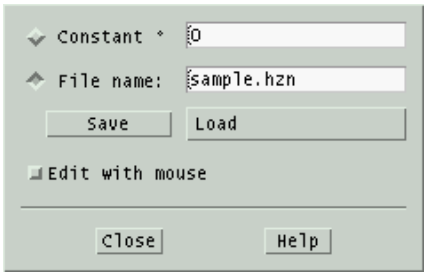
Save

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.

5.5.5 Horizon



XEphem allows you to create a file describing your local horizon. This window gives you two ways to define your local horizon, and a handy way to edit and save a horizon description. One way to define a horizon is just to specify one altitude that will be used at all azimuths. To use this method, type the desired altitude in the field provided, then type Enter or toggle the button labeled **Constant** On.

The other way is to draw your actual horizon profile interactively as follows:

1. Set the Sky View to display Alt-Az mode;
2. set Az to 0, Alt to 90, FOV to 180 so you see your entire sky;
3. click on **Edit with mouse**;
4. draw your horizon with the mouse;
5. when finished turn Edit with mouse back off;
6. enter a file name;
7. click **Save**.

Editing can in fact be performed in any mode but the above setup is the most natural. Reload the profile later using **Load**. As many profiles can be stored as desired. For example, if you observe from several sites, you can have a profile for each.

File format

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.
- Azimuth values range 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 Constant method.
- The second number is degrees above horizontal.
- XEphem linearly interpolates as necessary when drawing between the Az and Alt values in the file.
- Lines of any other form are ignored.

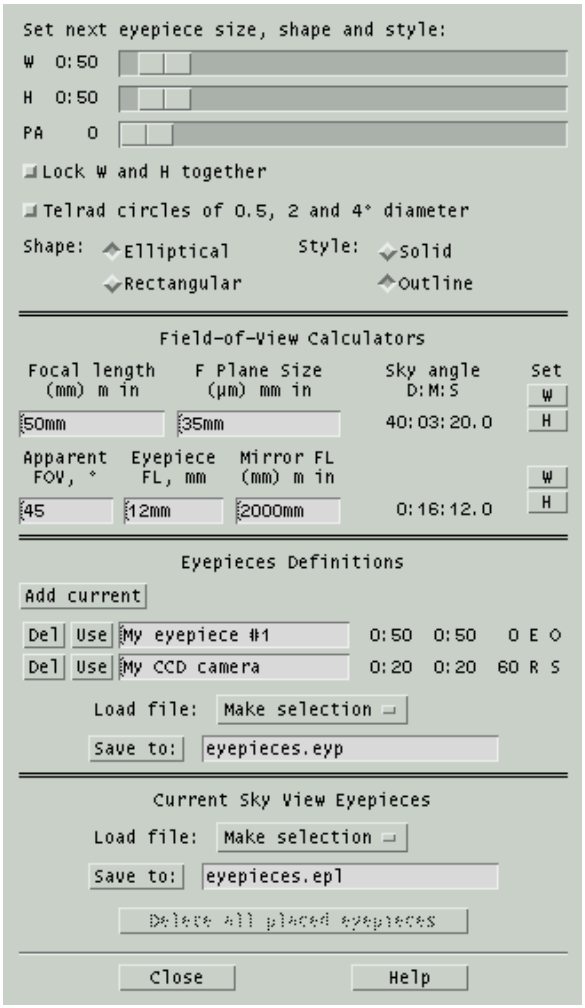
5.5.6 Field Stars

This activates the Field Star setup window. To display Field Stars, turn on the toggle under Options. See Field stars.

5.5.7 Favorites

This activates the Favorites setup window. See Favorites.

5.5.8 Eyepieces



This window allows you to specify the shape, position angle, 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 place 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**. When an eyepieces is place on the sky, both the RA-Dec and Alt-Az of the location are saved and the set matching the Display mode is used when the eyepiece is drawn on the Sky View. In this way eyepieces are fixed in both coordinate systems.

Set next eyepiece ...

Across the top are three sliders which set the **W**idth, **H**eight and **P**osition **A**ngle of the next eyepiece. Width and Height are shown in units of degrees:minutes, PA is in degrees east of north.

Below them is a toggle that will **Lock** the W and H sliders so they move together. This makes it easy to create eyepiece shapes that are perfectly round or square.

As a special convenience for and in deference to, there is a toggle which will create three open circles spaced to match the view through the **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.

Field-of-View Calculators

In the central portion of the Eyepiece window are two **calculators** 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 or the entire detector. 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 calculator 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.

Saving Eyepiece Definitions

This portion of the Eyepieces window allows you to **Add** the current eyepiece settings to a list of favorites. A simple name is chosen automatically but you may change this to be more meaningful to you. Each such eyepiece may be **Del**eted from the set or put to **Use** by using the buttons on the left. To the right of each eyepiece is a reminder of its width, height and a code letter for its shape and size.

The buttons below the table of favorite eyepieces allow you to **Save** and later **Load** the table to a file. These files have the extension **.eyp**. When saving, the new file is always created in the Private directory. When loading, files with this suffix are first checked for in the Private directory and if not found in the Shared directory. The suffix is automatically added if not entered in the file name field. The file named in the Save field is also the file that is automatically loaded when XEphem starts. This file name can be saved in the `Preferences » Save` window in the Skyview -- Eyepieces section as DefFile.

Saving Sky View Eyepiece Placements

This portion of the Eyepieces window allows you to **Save** and later **Load** the set of eyepieces currently defined on the Sky View to a file. These files have the extension **.epl**. When saving, the new file is always created in the Private directory. When loading, files with this suffix are first checked for in the Private directory and if not found in the Shared directory. The suffix is automatically added if not entered in the file name field. The file named in the Save field is also the file that is automatically loaded when XEphem starts. This file name can be saved in the `Preferences » Save` window in the Skyview -- Eyepieces section as PosFile.

Delete all placed eyepieces

After at least one eyepiece has been placed in the Sky View, a button at the bottom of this window will become available to permanently **Delete all placed eyepieces** currently anywhere on the Sky View. You may also delete them individually from the Sky View from the right-click popup or if you just want to temporarily turn all Eyepieces off and back on later, use the Eyepieces control in the `Control » Options` window.

Close

Across the bottom are buttons to **Close** the window and **Help** to get more information. Closing the window has no effect on eyepieces already placed in the Sky View.

5.5.9 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. The coordinates may be set from or used to repoint the Sky View. See Coordinate converter.

5.5.10 User annotation

This selection brings up a window which allows text and lines to be drawn over the image. See Annotation.

5.6 Sky View Images menu

The Images menu can bring up three windows.

Load and save...

This window controls loading local FITS files, downloading them from the Net, and saving them locally.

Analysis tools...

This window provides a variety of image analysis and processing tools. Settings made in this window can also effect what the mouse does in the Sky View when an image is being displayed.

WCS Solver...

This window provides a means to add World Coordinate System headers to a FITS file. With WCS, XEphem (and many other programs) can compute the RA and Dec of each pixel in the file, not just its X and Y pixel coordinates. This capability opens the door to many interesting possibilities. The algorithm performs a pattern match between the star-like artifacts in the image and the GSC and/or USNO star catalogs.

5.6.1 Load and Save FITS images

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 WCS Solver tool.

Resizing the window will change the size of the scrolled text area displaying the FITS header fields.

Open FITS file

Clicking on the option menu will display a list of all FITS files in the Private and Shared directories in a popup menu. All files with the name extension .fts, .fits, or .fit will be included. Clicking on a file in the popup list will display it.

Download

This button heads up the section for downloading Digital Sky Survey images from the Internet You may choose 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 is 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.

Clicking Display 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 » Syetem 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. The button labeled **Set time** 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. EPOCH must be a decimal year; JD must be a decimal Julian Date; or DATE-OBS must be either in ISO 8601 format (YYYY-MM-DDTHH:MM:SS), YYYY[/-]MM[/-]DD, or MM[/-]DD[/-]YY where YY is assumed to be the number of years since 2000 if less than 50 otherwise years since 1900.

In order to be displayed by XEphem, the header in a FITS file must contain at least the mandatory fields SIMPLE, BITPIX, NAXIS, NAXIS1, NAXIS2 and END. Only files with BITPIX 8 or 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 supported at this time.

Note: 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].

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 turned on, 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. You may also type in your own name.

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 Contrast.

File watch:

This feature allows XEphem to automatically discover and display FITS files that were created by another program. When **Watch** is turned on, XEphem will try to open the *watch* file named in the text field provided here approximately once each second and display the file named on the first line of the *watch* file. If successful XEphem removes the *watch* file as a means to handshake the image has been displayed.

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 on the same computer running camera control software unrelated to XEphem.

A further note to implementors: XEphem also supports the *watch* 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.

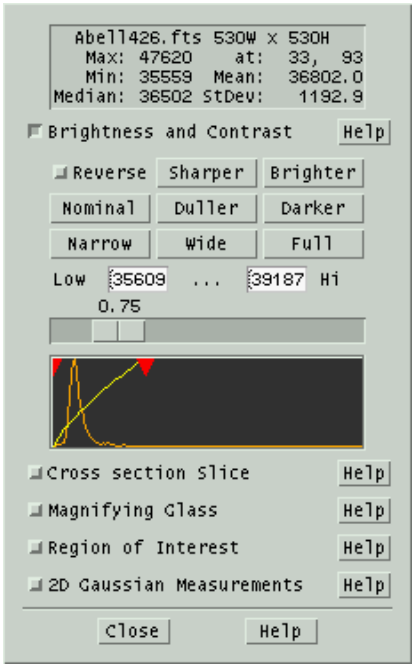
5.6.2 Image Analysis Tools

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. Always present at the top of the window is a block of basic information about the image. The statistics ignore a border of 8 pixels. The information shown is: file name; width and height; value and location of brightest pixel; value of dimmest pixel; mean, median and standard deviation of all pixels.

Note 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].

5.6.2.1 Brightness and Contrast



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


This section may also 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.

Low and **Hi**

> are text fields in which one may type (or paste) the exact pixel values to be assigned to black and white. A new value takes effect when Enter is pressed. These fields also always show the current settings installed by any of the shortcuts.

Gammas

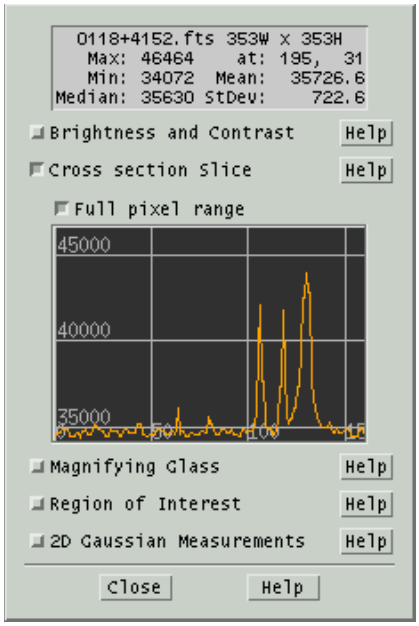
> is set using the scale just above the graph. The mapping from pixels to display colors is a power function. Values of gamma less than 1 emphasize dark pixels, gamma values greater than 1 emphasize bright pixels.

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.

5.6.2.2 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.



> **Full pixel range** toggle when set scales the vertical scale to the full range of pixel values in the image, else scales to the pixel range from Lo to Hi as defined in the Brightness and Contrast section.


This section may also be opened using the button in the right Sky View toolbar that looks like a slice of bread.

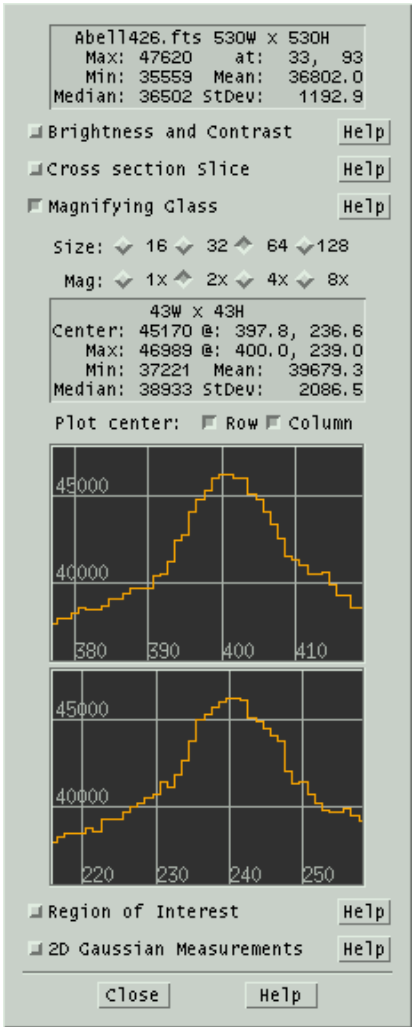
5.6.2.3 Magnifying Glass

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 **Mag**nifying 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:

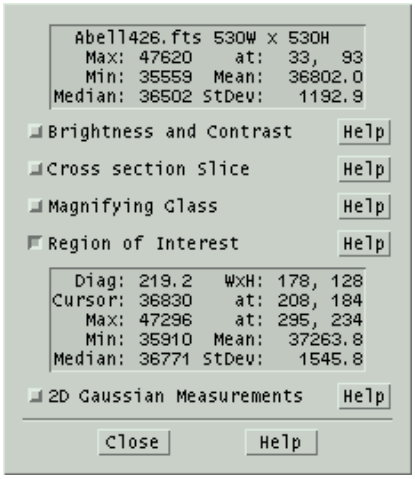
- Size of the area under the glass;
- Value and location of the center;
- Value and location of the largest pixel under the glass;
- Value of the minimum pixel;
- Mean value of all glass pixels;

- 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.

5.6.2.4 Region of Interest



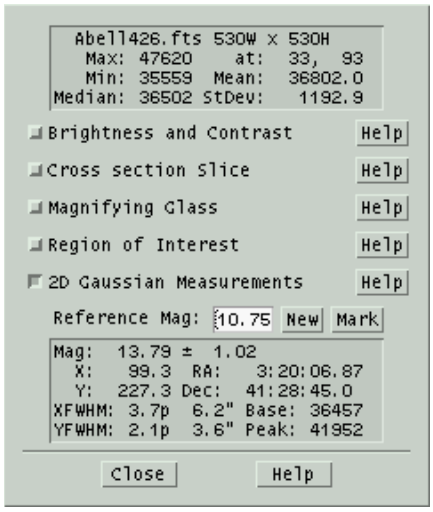
This section lets you use the mouse to draw a rectangle over the image and get statistics about the pixels within this region. The area is the same as that which can be used to specify a region in which to zoom.


This section may also be opened by the right toolbar button that looks like a boxdrawn 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 ROI pixels;
- Median value of all ROI pixels;
- One Standard Deviation of the pixel values about the mean.

5.6.2.5 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 Chi square 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 correction, linearity 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 over differences of several magnitudes.

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 several 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.

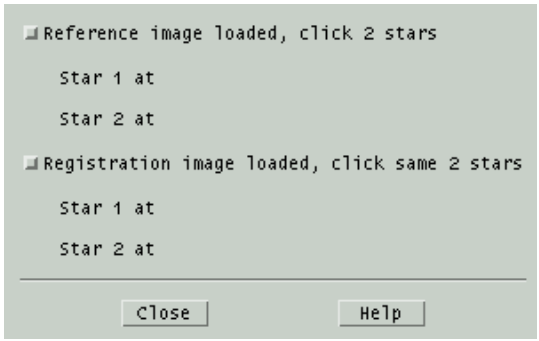
After any star has been measured, it can be made the reference by clicking on **New.** Clicking **Mark** will draw a small circle in the image around the current reference star in case you lose track of it.

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 in the Sky View 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 too. 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.

5.6.3 Registration



This window lets you register, or align, one or more images to a reference image. The motivation for this feature is to make a movie of a moving object that has been captured in several images. Load the reference image into a new Movie then load each additional image after it is aligned.

The alignment algorithm requires two stars that appear in each image. Using two stars is the most general method of defining a 2D coordinate system and is used for its robust performance. It is possible to use just one star, but the technique requires the software to make assumptions about matching features in the image. We feel the slightly larger burden of defining two stars is worth the results. When choosing the two reference stars, select stars that are well separated in both rows and columns, isolated from neighboring stars, moderately bright and well formed.

To begin, load the reference image into Sky View and adjust the contrast or other visual effects as desired. Then click the first toggle in the window. The cursor will change over the Sky View to a small cross. Place the cursor

over one reference star and click; you will see the Gaussian centroid image coordinates of the star appear in the registration window for Star 1. Now choose a second reference star and click again. You will see its coordinates appear for Star 2, the cursor will revert back to the original style and the toggle button will pop back out. If you ever want to change the reference image choose different reference stars, you can turn on the top toggle again at any time and restart the procedure. This is a good time to delete any frames currently in the Movie tool and add the reference image to form the first frame of a movie.

Now you can load a second image. Again, adjust contrast and so on as desired. Click on the second toggle in the registration window and proceed as before to click on *the same two stars* in the second image. Be sure to click on the two stars in the same order, so that the first star clicked when defining the reference stars is also the first star clicked when working on the second image.

As soon as the second star is clicked on the second image, the image will be transformed using translation, scaling and rotation in such a way as to align the two stars with their location in the reference image. The contrast settings are preserved for you even though the image pixel statistics have changed due to the addition of new black pixels where the images do not overlap and the loss of pixels that do not fit over the reference image. If the results look useful, add it to the Movie.

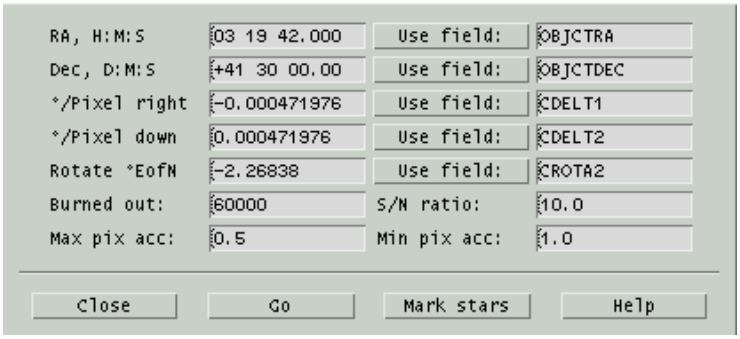
You may repeat the process of aligning additional images with the reference image for as many images you like.

Note that while either toggle is turned on in the registration window, the other image analysis tools are temporarily disabled. Note also that the algorithm used to transform the image to match the reference image is designed primarily for speed. The stars in the transformed image are a little distorted and we recommend you not use these images for precise photometry or astrometry.

5.6.4 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. See Field stars.

The solver will be invoked automatically whenever a FITS file is loaded whose header includes all the seed fields but does not already have a WCS solution.



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.

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 solution will be saved with the image and searching will not be needed next time.

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.

WCS Solver Tutorial

The first step is to supply suitable seeds values for the center of the image, the image scale and any suspected rotation. If the FITS image header contains fields with these values, enter the names of the fields in the spaces provided and they will be extracted automatically when the image is loaded. If the header does not contain this information, or the units are not correct, then seed values must be entered manually in the fields provided. Note that the pixel scale values must have the correct sign since the algorithm automatically takes into account rotation but not flipping.

The second step is to set the SNR value so that Marking stars finds most of the brightest and well-formed star-like objects in the image, without also finding bogus star candidates. Also, if the image was over exposed so that very bright stars are washed out, eliminate these by reducing the value for burned out stars.

Once good stars are being marked, the last step is to indicate how accurately star centroids can be determined and how accurate any solution is likely to be using the bottom two fields of the form.

Another issue is to use an appropriate field star catalog. More stars is not necessarily better. For example, the GSC 2.2 goes to mag 18 but also tends to have more bogus entries near very bright stars. If your image contains a very bright star, take note of the field stars that are near it; you might do better with the GSC 1.2 than 2.2 catalogs.

After adjusting any field, click Go. If a solution is found, the stars used in the fit will be marked and

statistics about the fit will be displayed.

This algorithm has proven to be very robust over the years. With a little practice it can usually be made to work quite well.

5.7 Sky View Favorites menu

This brings up a menu of the current Favorite objects. Clicking 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. Favorites may be managed from the `Control » Favorites` window. See Favorites.

5.8 Sky View Telescope menu

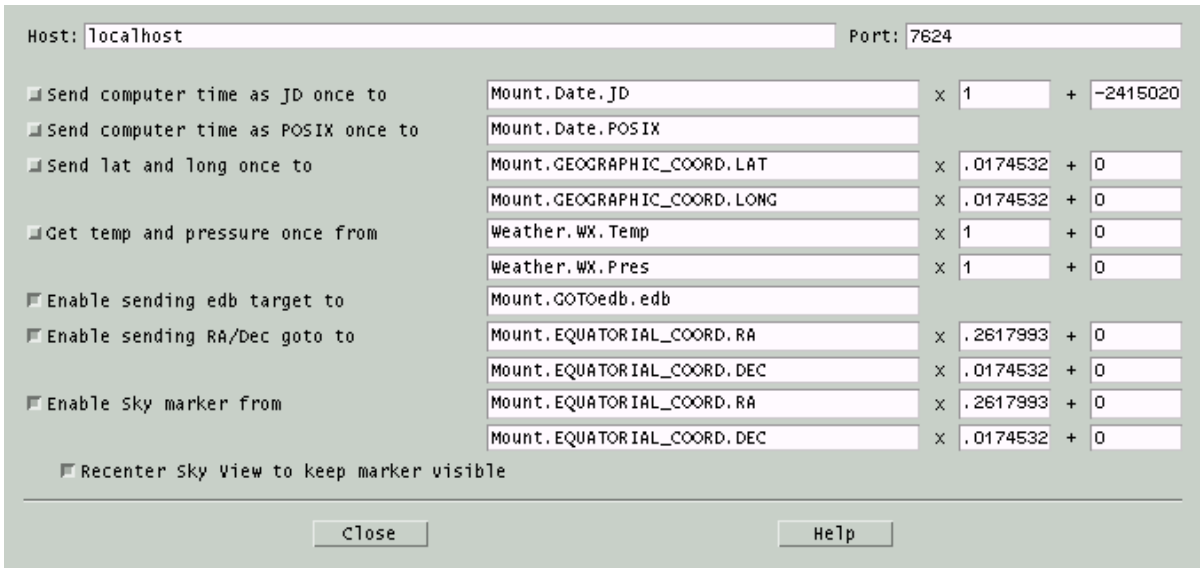
The Telescope menu in Sky View allows you to connect to and control a telescope and, if using the INDI protocol, any other instrumentation whatsoever. The control can be performed via a simple fifo connection, or a much more flexible INDI interface. For a complete description of the INDI protocol, please download the reference specification from http://www.clearskyinstitute.com/INDI/INDI.pdf. Here we only describe the INDI configuration window, the INDI control panel, testing the INDI system using the sample drivers, and finally the simple fifo interface.

Regardless of which means is used to send a new position to a telescope, the menu contains a history list of targets. Clicking on one of these will send that target again. A button is available to erase the list at any time.

5.8.1 INDI Test Drivers

Beneath the source directory of XEphem is a directory `tools/indi`. This contains several sample INDI drivers that together simulate an entire observatory. Please read the README and follow the instructions to build and run the sample drivers. This will allow you to perform a live test of XEphem's INDI windows to be described next.

5.8.2 INDI Configuration window



The top row of this window contains two text fields by which you to specify the TCP/IP host and port name to which a connection is to be made to an INDI driver or server. The default values are suitable for running the test drivers mentioned above.

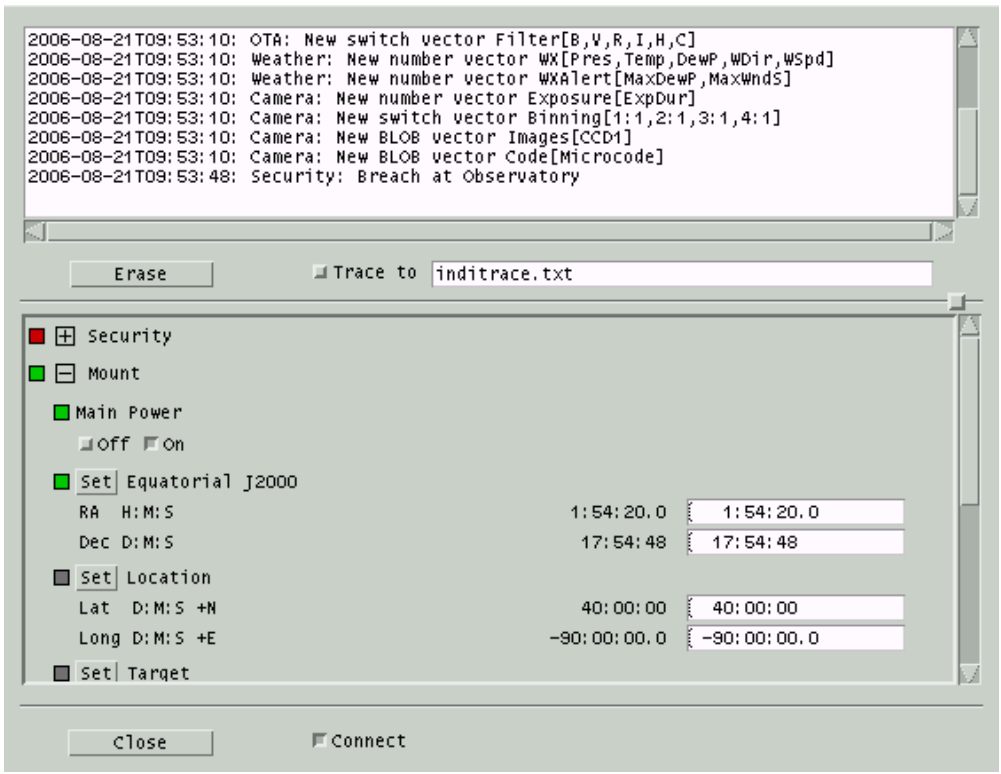
The remaining rows define the mapping between internal XEphem functionality and the external INDI devices. All information flows over the INDI protocol based on Properties. Each property is defined as a Device, a Property and an array of one or more Elements. The INDI protocol does not prescribe the names or the meanings of Properties, it is up to the client and servers to agree. Recommended practice will evolve as community participation matures. The sample drivers supplied with XEphem make some possible choices for properties and names.

The default settings in the Configuration window are the correct mappings for these sample drivers. The idea is to specify the Device.Property.Element that corresponds to each purpose. The Configuration window also allows entering a multiplier and offset that is applied to the INDI value to compute the value in units used within XEphem. For example, the units for Mount.EQUATORIAL_COORD.RA are hours but XEphem wants this value in radians, hence the multiplier set to 0.2617993. When connecting to drivers for which the name mapping is not yet known, one technique for discovering their Properties is to watch the INDI Control Panel (described next) for each new Property that is reported when connecting toan INDI server.

One of the options is whether to display a **marker** at the telescope position on the Sky View. Below this ia a toggle button to specify whether the Sky View will automatically **Recenter** in order to keep the telescope Marker in the field of view. The option applies both to INDI and fifo marker commands. When Recenter is On, then the telescope Marker is automatically turned off whenever the Sky View is manually adjusted (the rationale being that one will most likely not want the Sky View to bounce back to the telescope position after having been manually changed).

Note that the sample drivers do not support all XEphem functionality. For example, the sample drivers do not support being sent a new time and date. This is included in XEphem in case it is useful someday for some other driver and to illustrate how XEphem stores dates internally as a modified Julian date, ie, with an offset of 2415020 removed.

5.8.3 INDI Control Panel



This window shows the realtime operation of an INDI server. It is divided into a top and bottom section. The proportion of screen space used by each half may be controlled using the sash control located just about the bottom scrolled area.

The top half is a scrolled text area that shows the status messages arriving from each device. Each message is preceded with a time stamp, followed by the Device followed by the message text. The **Erase** button will permanently remove all messages from the scrolled text. Clicking on the **Trace to** button will append the current set of messages to the file named in the text field to the right and append all further messages to this file until tracing is turned off.

The bottom half shows each INDI Device, Property and Element to which XEphem is connected. Each Device may be expanded or collapsed to control screen space. The entire list can be scrolled up and down. The **Connect**

button controls whether XEphem will connect to the INDI device whose host and port are defined in the INDI Configuration window. If a connection is successful, each of the reported Properties will appear in the bottom scrolled area.

Under each Device is a list of its Properties. Each INDI Property may be in one of four states: Idle, Ok, Busy and Alert. These are shown as a light to the left of the Property colored gray, green, yellow and red, respectively. To the left of each Device is also a light, colored the same the highest activity color of any of its Properties. In this way the status of the most active Property can be determined even when a Device is collapsed in the window.

INDI Properties can be one of four types. These are Numeric, Text, Switches and Lights. The first three may be read-write or read-only. A light is always considered read-only (set only by the Device, not by the operator). Each Element of each Property is shown on one line. The left side of the line is the label. Following the label is the current value and, if read-write, followed by a text field for entering a new value. Read-write Properties will have a push button to the left of their name to set a new value; pressing Return in the text field will also set a new value. Switches will show each switch with their label. Switches may be defined to operate according to the rules one-of-many, any-of-many and at-most-one.

5.8.4 FIFO Control

Completely separate from the INDI interface, Sky View implements two simple fifos for communicating with a telescope control dæmon or other processes or scripts. Both fifos must be in the Shared directory.

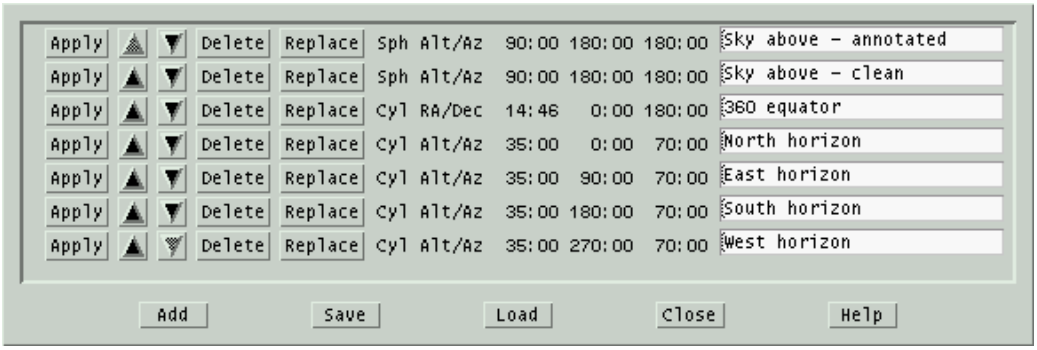
1. **Inbound:** A marker may be placed on the Sky View by writing a text string to the fifo named **fifos/xephem_in_fifo**. The format allows for sending either equatorial or horizon coordinates. To send an equatorial coordinate, the format is "`RA:X Dec:Y`", where X and Y are in radians at epoch 2000.0. To send a horizon coordinate, the format is "`Alt:X Az:Y`", where X and Y are in radians. The Sky View center pointing position will be changed if necessary to make the marker visible. XEphem attempts to open this fifo each time the Sky View window is opened and closes it when the view is closed.

2. **Outbound:** If a process has the fifo named **fifos/xephem_loc_fifo** open for reading when the Sky View popup menu is activated, then the menu will offer a button to send the cursor position to this fifo. The format is the same as a line in .edb format. If it is not already open XEphem attempts to open this fifo each time the popup is activated, and leaves it open until writing to it fails. Each position sent to the fifo is added to the Telescope history list.

5.9 Sky View History menu

This is the Sky View History control window. All Sky View Options, Filter settings and pointing values may be saved in a History entry to make it easy to configure the same way again at a later time. The **Edit** pushbutton in the History pulldown menu brings up this window. The additional pushbuttons in the History pulldown menu correspond to each defined History entry and make it easy to apply any one history entry without opening the History control window.

The control window shows the current set of History entries, one per line. The left portion of each line contains several controls, described below. The center portion summarizes the entry, showing the display mode, coordinate system, center position and field of view. The right portion provides a text field to give the entry a name. This is the name which appears in the History pulldown menu.



The controls for each History entry are as follows:

Apply

puts the entry into effect, in the same way as choosing it from the pulldown menu.

Up
Down

moves the entry up or down in the list.

Delete

removes the given entry.

Replace

replaces the entry with the current Sky View settings.

The buttons across the bottom allow for additional control of the History list as a whole:

Add

captures the current Sky View settings and creates a new History entry. A default name will be created but you should probably change it to something more descriptive if you plan to Save the list.

Save

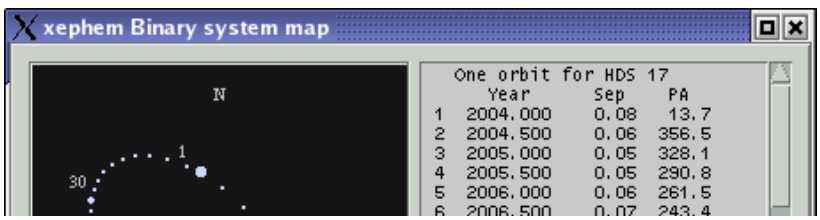
writes all of the current History entries to a file. The file name is **xephem_skyhist** and will be created in the Private directory. You really don't want to know the format of this file.

Load

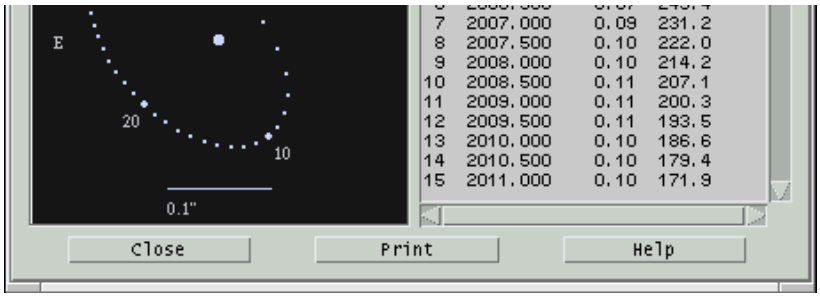
reads an existing file of History entries that has been previously Saved and makes them the current set.

5.10 Sky View Binary Star Map

This window displays a map of a binary star system and a matching ephemeris. It is displayed from the popup that appears when the mouse is right-clicked over a binary object



in the Sky View.



The map is at left, oriented with equatorial N up and E left, as on the unaided sky. Each star is drawn in a color according to its spectral class. The primary star is drawn at the center. A scale at the bottom shows the sky dimensions of the plot.

If complete orbital elements are available, one orbit is plotted at equal time intervals marked by small dots. The largest dot in the orbit marks the position of the secondary nearest to the current XEphem time, medium size dots mark other locations each ten steps.

If only discrete positions for the secondary are known, the plot is simply one dot for each.

The table on the right lists the position of each plotted secondary position. The columns are the dot number, year, separation in arc seconds and position angle as degrees East of North. The separation and position angle at the current XEphem time are available in the *More info* pull-right menu in the Sky View popup.

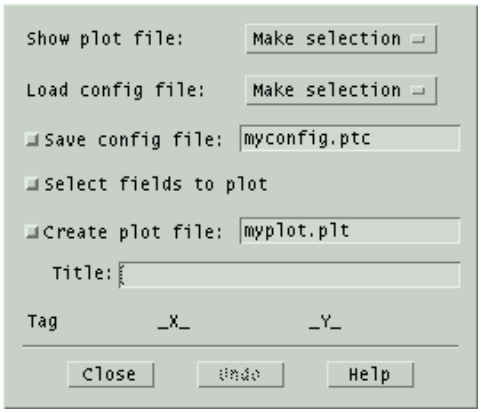
The **Print** button will print the map and the list.

6.0 Tools menu

The tools menu provides access to a variety of functions.

6.1 Plot values

This window controls the plot generation and display functionality of XEphem. You may select most numeric information displayed throughout XEphem, in pairs, to form x/y coordinates of a plot. You may select up to 40 such pairs. You then specify a file in which to write the plot information. XEphem adds one line of information to the file for each x/y pair each Update iteration step. XEphem can then plot any such file on the screen.



Selecting data to plot

Click the toggle labeled **Select fields to plot** to make each field in the other windows 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 table. Use the **Undo** button to make changes. You may also associate a tag with each line, up to 8 characters in length. 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 windows to their normal operational appearance by deselecting the same toggle button.

Saving and restoring a plot configuration

To save this configuration so it can be loaded later, specify a file name and click **Save config file**. It will be saved in the Private directory. The plot entries will be savde in addition to the plot title field. The extension for plot configuration files must be **.ptc** and will be added automatically if left off. A configuration file may be loaded by selecting it from the option popup menu to the right of **Load config file**. The menu will list all files that reside in the Shared and Private directories with extension .ptc. Note

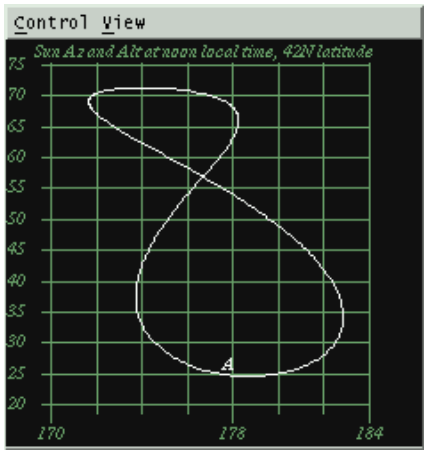
that reloading a configuration only recreates the Plot's tag, x and y description; to be useful, the fields to which the reloaded configuration refers must be made active independently.

Specifying the plot file name and title

Type the name of the file to be used to contain the plot information in the text field provided. The extension must be **.plt** and will be added automatically if left off. When XEphem first needs to write to the file, it will first check for the existence of the file and, if it already exists and the Confirmations Preferences is On, ask whether you wish to append to the file or overwrite it.

Enter a short **title** for the plot information in the text field provided. When XEphem first writes to a plot file, it will place the contents of the title text field, 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 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 **Create plot file** toggle button when ready. Now each time XEphem goes through one Update 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 in the Main window looping section 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 click the Update button manually for each iteration.

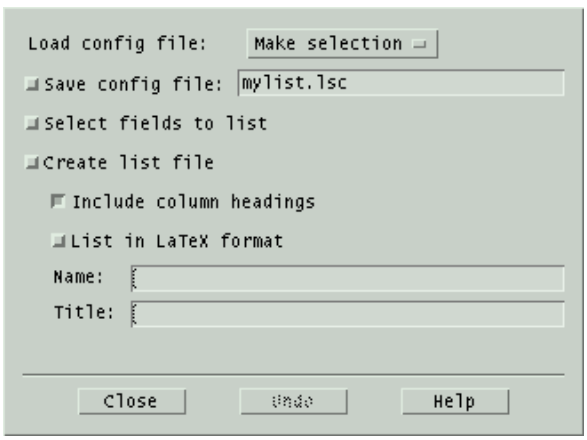
Once all the desired data has been entered into the plot file, toggle the plot button back off to flush all data and close the file. The windows that contain each of the fields used in the plot need not be visible while the plot is being generated. However, each field must be active, for example its row and column must be selected if they are in the Data table.

Viewing plot files

Existing plot files may be viewed by choosing it in the menu to the right of **Show plot file**. The menu will list all files that reside in the Shared and Private directories with extension .plt. 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.

6.2 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. The text in these columns looks 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 define each column of the listing. As you make the selections, they are listed in the table here. Use the **Undo** bottom to make changes. Once all the column choices have been made return all the windows to their normal operational appearance by deselecting the same toggle button.

Saving and restoring a plot configuration

To save this configuration so it can be loaded later, specify a file name and click **Save config file**. It will be saved in the Private directory. The name of each list item will be saved in addition to the column and latex options and title field. The extension for list configuration files must be **.lsc** and will be added automatically if left off. A configuration file may be loaded by selecting it from the option popup menu to the right of **Load config file**. The menu will list all files that reside in the Shared and Private directories with extension .lsc. Note that reloading a configuration only recreates the Listing fields; to be useful, the fields to which the reloaded configuration refers must be made active independently.

Specifying the listing file name and format

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.

Choose to print the file in **LaTeX** table format by pressing the given button before beginning to list to the file.

When **column headings** are turned on, they are written to the output file each time the file is opened.

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 in the Main window looping section 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 click 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. The windows that contain each of the fields used in the listing need not be visible while the list is being generated. However, each field must be active, for example its row and column must be selected if they are in the Data table.

6.3 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. The complete list is:

```
+ - * / && || > >= == != < <= 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.

Compiling the function

Once the function has been created as desired, it must be compiled by selecting the **Compile** button (or by pressing the 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 an astronomical calculator even when not actually solving anything.

Selecting a goal

You may choose from any of four evaluation algorithms, as selected by the trio of radio buttons. **Find Maximum** and **Find Minimum** will solve for a maxima or minima of the function, respectively. **Find 0** will solve for a time when the function evaluates to zero. **Binary** will keep incrementing time by Step 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 desired accuracy value. Note that this method of detecting convergence is not based on the value of the search function itself.

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, referring now to the looping section of the Main window, each time an Update occurs 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 clicking Solver is Active back off.

Saving and restoring a solver configuration

To save the Function, Goal and Accuracy so it can be loaded later, specify a file name and click **Save to**. It will be saved in the Private directory. The extension for solver configuration files must be **.svc** and will be added automatically if left off. A configuration file may be loaded by selecting it from the option popup menu to the right of **Load file**. The menu will list all files that reside in the Shared and Private directories with extension .svc. Note that reloading a solver configuration only recreates the solving conditions; to be useful, the fields to which the reloaded Function refers must be made active independently.

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 or listing whether or not actual solving is turned on.

The windows which contain the fields used in the function being solved need not be visible while solving is in progress. However, the field must be active, for example their row and column must be selected if they are in the Data table.

The **Close** button removes the Solving window from the screen; it does not effect actual solver operation in any way.

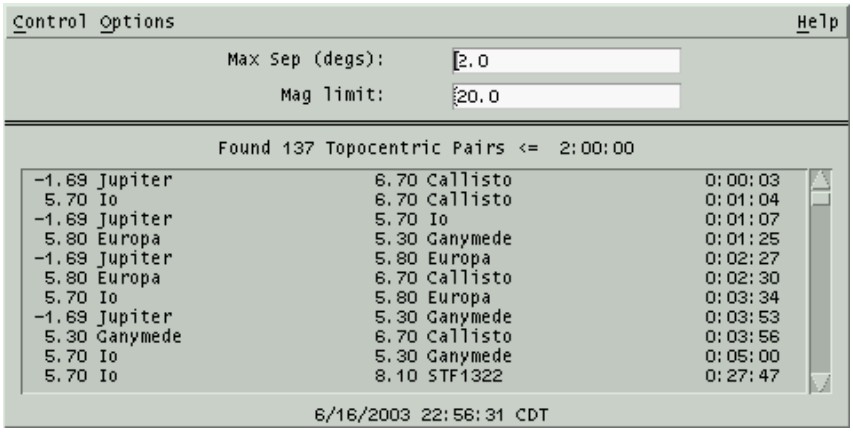
A successfully compiled function is evaluated each time XEphem updates. Whenever the function is compiled it is also evaluated using freshly updated values. In this way, the Solve window can actually be used as an arbitrary astronomical calculator at any time, whether or not solving is actually active.

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 modest step size that will reach the the nominal solution within a few steps. 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.

Each plot file may be added to a movie loop or overlayed with text or graphical annotation using the menu items in the **Control** menu of each plot.

6.4 Find close pairs

This window allows you to scan the list of objects currently in memory brighter than a given magnitude for all pairs which are separated by less than a given angular distance. Separations will be topocentric or geocentric depending on the Equatorial Preference in the Main menubar. The scan does not include field stars.



These are the essential steps:

1. Set the desired maximum separation, in degrees, and faintest magnitude.
2. Set other options via the Options menu, described below.
3. Start the scan via the Run button in the Control menu.
4. When the scan completes, all pairs meeting the criteria will appear in the scrolled list.

The columns in the list are:

- Object 1 Magnitude
- Object 1 Name
- Object 2 Magnitude
- Object 2 Name
- Separation, in Degrees:Minutes:Seconds

The entries are sorted in increasing order of separation. The total number of pairs found 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.

6.4.1 Close Pairs Control menu

Run

This performs one scan. The XEphem cursor will change to the Watch shape until the scan is complete at which time the results appear in the scrolled list.

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 list to a file. A window is presented which allows you to enter a file name. The file is written when you click Ok.

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 Pairs window. Note that the **Auto run** option is disabled when the window is closed.

6.4.2 Close Pairs Options menu

Auto run

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 scans are not performed if the Close Pairs window is closed.

Auto list

When this option is active, the results of each scan are automatically appended to the file last specified in the **List to file** window. This works whether the scan was performed explicitly via the `Control » Run` command here or implicitly via an Update from the Main window and the **Auto run** option is active.

Omit fixed pairs

When this option is active, pairs of Fixed objects are not listed.

Omit planet's own moons

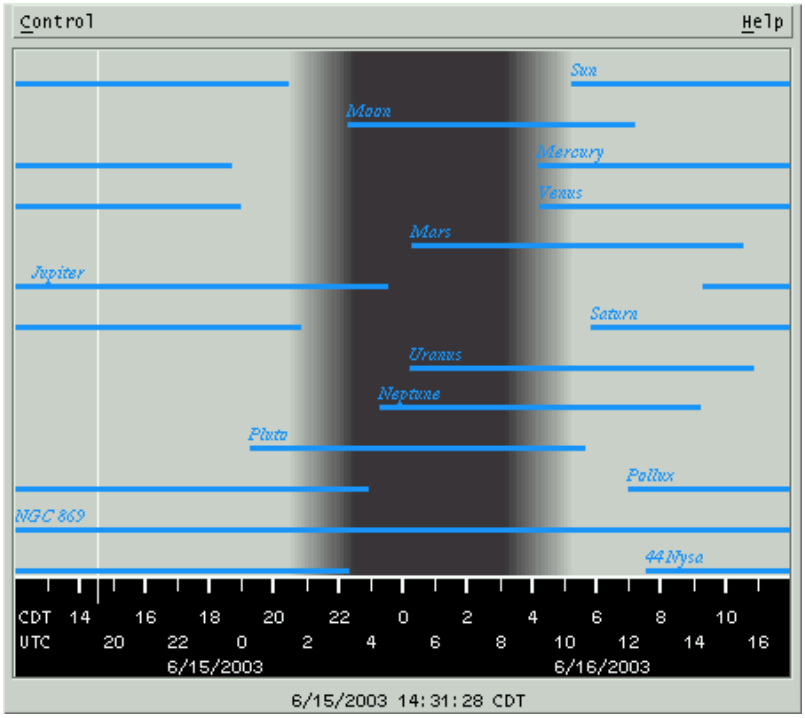
When this option is active, pairs for which both objects are part of the same planetary system are not listed.

6.4.3 Close Pairs Algorithm

The sky dome is broken into bands of constant Dec with height equal to the given separation. The database is scanned once and each object brighter than the given limit is dealt into its band and the one adjacent in the direction of the North pole. Each band is then sorted by RA. Each band is then scanned for close pairs, with rapid cutoff detection due to the sort. The final list is then sorted by separation, and displayed.

Total time is strongly influenced by the number of pairs in the result. So when using wide separations it helps to use relatively bright limiting magnitudes.

6.5 Night at a Glance



This window displays a 24 hour period 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 window Night section.

Overlayed on the gray background is one horizontal line for each Favorite. The lines show when the object is above the horizon, the altitude of which is defined in the `View » Data Table » Control » Setup` horizon parameter. The lines on the diagram pack closer together as the number of objects to display increases; if things get too crowded try turning off some of the Favorites.

NAAG Control menu

One color toggles whether objects are drawn all in one color or according to their Sky View colors.

Print...
Favorites...
User annotation...
Add to movie...

These buttons provide convenient access to these facilities.

NAAG mouse

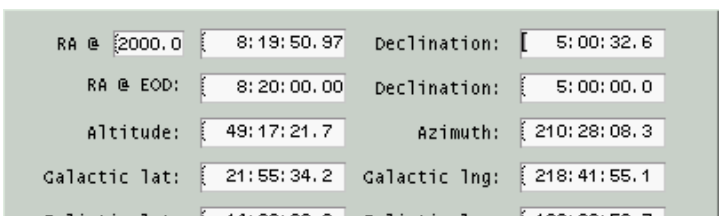
Right-clicking near an object's line will pop up a menu containing its rise, transit and set data. This information is with respect to the day in which the click occurred.

If the mouse is clicked far from any object, then just the time at that horizontal position is presented.

The menu always includes a button showing the exact moment corresponding to the mouse click position. Clicking the button sets the main XEphem time to this moment.

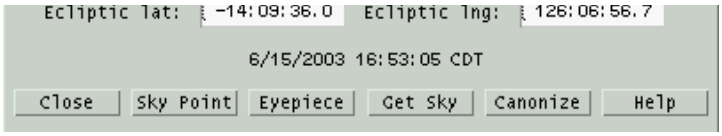
An interesting exercise is to set up a time loop with a Step size of a few days and watch how the rise and set times of objects and the amount and timing of night time are effected throughout the year.

6.6 Coordinate converter



This window performs simple conversions among several common astronomical coordinate systems. Simply edit (or paste) any coordinate 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 top row are astrometric RA and Dec precessed to the given equinox year, or enter EOD for apparent coordinates at the current epoch. Unlike the other fields, edits to the equinox field only take effect on Enter.

The next row are RA and Dec using whatever is set in the Main Window.

The controls across the bottom perform as follows

Close

Closes this window

Sky Point

Centers the Sky View at the current coordinates.

Eyepiece

Places an eyepiece in the Sky View at the coordinates shown. The Sky View is not recentered. In order to be drawn the Sky View Eyepieces Option must be turned on.

Get Sky

Loads each field from the current center position of the Sky View.

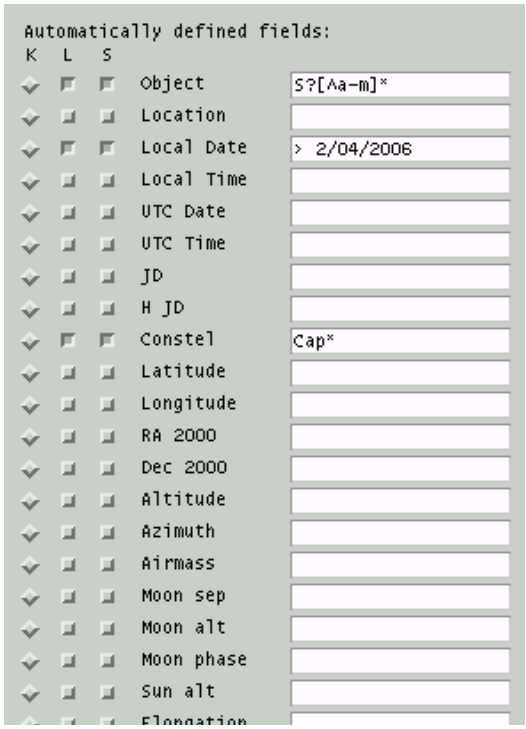
Canonize

Reformats each field in a consistent manner for easier viewing.

6.7 Observers logbook

This tool lets you store observing circumstances and notes. It is typically used when making observations at the telescope.

When this window is open, the popup you get when right-clicking on an object in the Sky View will contain a selection **Add to logbook**. Clicking on this choice will automatically fill in the top section of fields in the logbook pertaining to observing circumstances and object information. To these fields you may add your own **Notes** in the scrolled text area at the bottom, and equipment or **User defined fields** if desired.



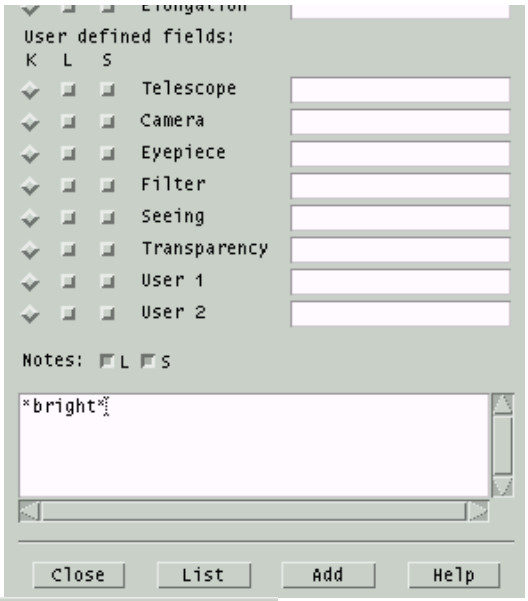
There are two interesting controls available across the bottom as follows:

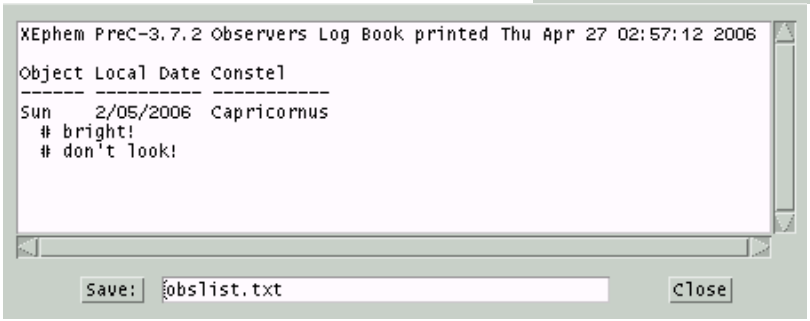
List

This brings up a scrolled list showing all entries in the logbook whose fields match those selected in the **S** column. The field may contain glob patterns for a textual match or be preceded with < or > for a numerical range

match. Only those fields selected with the **L** column will be shown, and they may be sorted by the field selected in the **K** column.

You may **Save** the resulting scrolled list to a text file using the file name field provided. Right-clicking on an entry in the scrolled list will mark the location of that log entry in the Sky View based on its RA2000 and Dec2000 field values.





Add

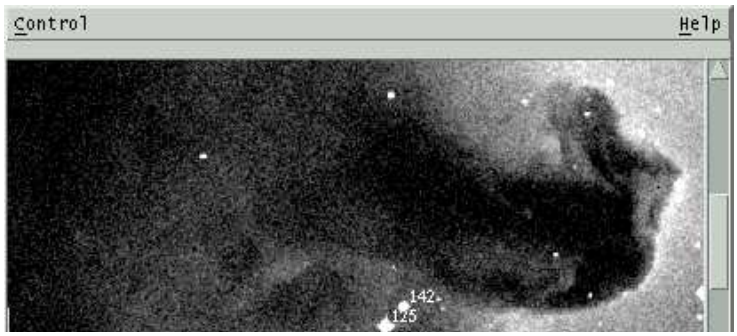
This will add the current record to the logbook file. In keeping with the convention that log books are written in ink, there is no mechanism provided for editing or removing existing entries. Of course, one may always edit the log file independently.

File format

The Observers logbook is a text file in XML format. The format should be pretty self-explanatory. The file name is **xelogbook.xml** in the Private directory. The entire logbook is contained in one XML element tagged **xelogbook** with a version attribute 1.1. Each log entry is in an element tagged **logentry**. Within each logentry is one element named the same as the label in the window, sans spaces if any. The date fields are stored in the user's preferred format.

6.8 Movie loop

The Movie tool allows you to capture any number of View, Night at a Glance or Plot windows and collect them into a movie. The frames of the movie can be viewed one at a time or you can set the rate to change from one frame to next automatically. There are many uses for this type of function. For example, you could make small changes in time and make a series showing the movement of



an asteroid through the solar system. Or use it to quickly blink between two FITS images, one with and one without a potentially new supernova. You might find the Image Registration feature useful to make these images.

The **Control** menu has entries to **Delete current** frame or **Delete all** frames of the movie. You may also **Save** the frames to individual PNG files. You must specify a prefix then each file name will be of the format prefixnnn.png where *nnn* will be a sequence number starting with 000. The files will be located in the Private directory. XEphem does not save the frames directly as an actual movie because there are many such formats and other tools available to collect the files into a movie in your preferred format. For example, you could convert the PNG files into GIF files using *pngtopnm* and *ppmtogif* tools from the netpbm toolkit then make an animated gif using whirlgif or gifsicle. Another possibility is to use *convert* which is part of the ImageMagick collection. Check your system before looking too far, these tools are often already installed on many UN*X systems.

Sliding the **Frame selection** scale will display the indicated frame. **Step +1** and **-1** will advance or back up by one frame. Frames may also be changed automatically by sliding the **Frames per second** scale to the desired rate. Changing the displayed frame manually by any means will automatically reset the frame rate back to zero. When moving through the frames automatically and encountering the last frame in the series, the sequence can either reverse and show each frame back towards the first or jump back to the first and move forwards again, depending on the **Bounce** toggle button.

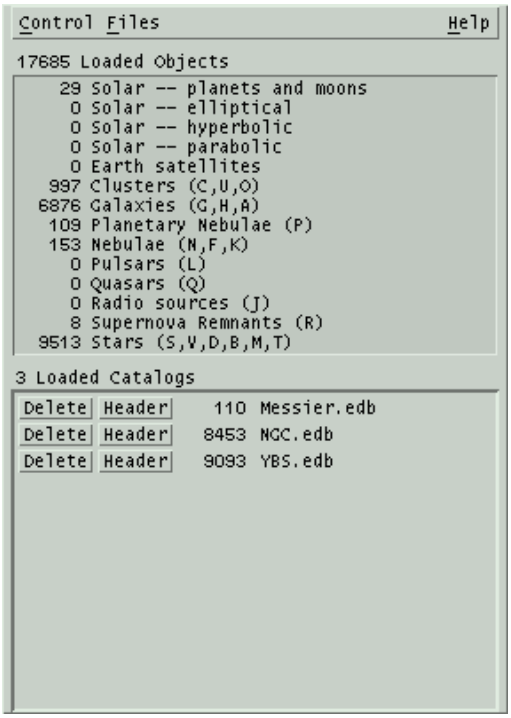
Each window whose contents may be added to a Movie will have an entry somewhere in its menu bar named "Add to movie". All such windows also support a short cut of typing Control-m to add the window to the Movie, so long as the cursor focus is located within the desired window.

7.0 Data menu

The Data menu offers several means to load, search and update the files XEphem uses for storing objects.

7.1 Files

This window allows you to load and delete database files to and from memory. These objects form what is referred to as the XEphem database. These do *not* include the field stars.



Click the **Files** menu to scan the Private and Shared directories and pop up a list of all .edb and .tle files found therein. Click on a file to load it into XEphem memory.

The top section of the window displays a count of each major type of object and the total number in the database. The counts include Favorites that are not also in the database.

The bottom section lists the catalogs which are currently loaded and the number of new objects they contributed to memory. Buttons to the left of each catalog allow the catalog to be **Delete**d from memory and to display the **Header** of the catalog.

The current list of loaded catalogs may be saved so it becomes the ones automatically loaded when XEphem starts. To do so, go to `Preferences » Save` and Save

the XEphem.DBInitialFiles resource under the Data Base category.

7.1.1 Files Control menu

Index...

This is a handy shortcut to open the object index.

Delete all

This deletes all loaded data. The files on disk are not effected.

Reload all

This reloads all catalogs currently loaded. This is handy when catalogs have been updated on disk, perhaps by some by some automatic means.

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.

Make Favorite when read 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 the list of Favorites. This feature also applies for files loaded when XEphem first starts.

Check alternate names

This toggle turns on or off support for XEphem 3.6's new support for alternate names. It is motivated entirely by performance. Recording alternate names and checking for duplicates is quite expensive and if not needed can speed up loading and deleting catalogs significantly. If this toggle is On then when a new database catalog is loaded each entry's alternate names, if any, will be checked for already being loaded and not loaded if found, and new alternates will be stored for display and subsequent checking. If this toggle is Off, only the first name of each entry is stored and no duplicate names are checked. Note that even when this option is Off, deleting a catalog still requires XEphem to remove all alternate names that might have been recorded when the catalog was loaded, so the full preformance advantage is only achieved if this option was off when each catalog is loaded.

Close

Closes the Data Base window.

7.1.2 File format

This section describes the format of an XEphem database file. The file name extension is .edb. See the next section for files containing two-line Earth satellite elements.

7.1.2.1 General format rules

- Each object occupies one line in the file.
- The order of objects in a file does not matter.
- Lines beginning with anything other than a-z, A-Z or 0-9 are ignored and may be used for comments.

- Lines are separated into Fields using commas (,).
- Fields may be further subdivided into Subfields with vertical bars (|).
- 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; or

    2. the year as real number as indicated by the presence of a decimal point, such as 1993.123.

7.1.2.2 Format Details

The first two fields are required and are always Name and Type. Remaining fields depend on Type.

Field 1 One or more object names, each separated by the Subfield separator, |. Any number of characters may be present in the file but XEphem only uses the first 20 characters of each name and only the first 20 names.

Field 2 Type designation. Consists of a single letter designation from the following set (case *is* significant):

- **f** fixed (or at most exhibits constant curvilinear proper motion)
- **e** heliocentric elliptical orbit
- **h** heliocentric hyperbolic orbit
- **p** heliocentric parabolic orbit
- **E** geocentric elliptical orbit, *i.e.*, Earth satellite
- **P** built-in planet or natural satellite name

If **Field 2** is **f** the object is fixed and the following fields and subfields are defined:

SubField 2A An optional SubField 2A can be added to further define an object class code, consisting of one character from the following list:

- A Cluster of galaxies
- B Star, binary. Deprecated as of version 3.6, gets turned into D internally. Use Field 2 type **B** if more than one position angle and separation or orbital elements are known.
- C Cluster, globular
- D Star, visual 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

Y Supernova

V Star, variable

SubField 2B If SubField 2A is one of T, B, D, S or V, optional SubField 2B may consist of up to two spectral designation characters, typically one letter followed by one numerical subclass designator. Two examples are O and G3.

If SubField 2A is any other class code, optional SubField 2B may consist of up to two additional characters to further describe the type.

Field 3 RA position coordinate, given as H:M:S.

SubField 3A This optional subfield may specify a proper motion in RA. It is in milliarcseconds per year on the sky, *i.e.*, `ΔRA*cos(dec)`.

Field 4 Declination position coordinate, given as D:M:S.

SubField 4A This optional subfield may specify a proper motion in Dec. It is in milliarcseconds per year on the sky

Field 5 Magnitude of the object.

Field 6 This optional field is the reference epoch. It is assumed to be 2000 if absent

Field 7 depends on SubField 2A

If SubField 2A is **G** or **H**

Field 7 Galaxy major axis, in arcseconds

SubField 7A Galaxy minor axis, in arcseconds

SubField 7B Major axis position angle, in degrees East of North

If Subfield 2A is **B** or **D**

Field 7 star pair separation, in arcseconds

SubField 7A reserved, set to 0

SubField 7B position angle, in degrees East of North

Otherwise Field 7 is optional but if present

Field 7 size of the object, in arcseconds. It is assumed to be 0 if absent.

If **Field 2** is **B** the object is a true binary pair and the following fields and subfields are defined.

SubField 2A An optional SubField 2A can be added to further define an binary class code, consisting of one character from the following list. This scheme is taken from the Washington Multiplicity catalog for compliance with the IAU 2003 recommendation.

a Astrometric binary

c Cataclysmic variable

e Eclipsing binary

x High-mass X-ray binary

y Low-mass X-ray binary

o Occultation binary

s Spectroscopic binary

t Single-line spectroscopic binary

u Double-line spectroscopic binary

v Spectrum binary

b Visual binary

d Visual binary with common proper motion

q Visual binary - optical

r Visual binary - physical

p Exoplanet

SubField 2B Up to two characters to specify the spectral class of the primary star, typically one letter followed by one numerical subclass designator. Two examples are O and G3.

SubField 2C Up to two characters to specify the spectral class of the secondary star, typically one letter followed by one numerical subclass designator. Two examples are O and G3.

Field 3 RA position coordinate, given as H:M:S.

SubField 3A This optional subfield may specify a proper motion in RA. It is in milliarcseconds per year on the sky, *i.e.*, `ΔRA*cos(dec)`.

Field 4 Declination position coordinate, given as D:M:S.

SubField 4A This optional subfield may specify a proper motion in Dec. It is in milliarcseconds per year on the sky

Field 5 Magnitude of each star in the pair.

SubField 5A Magnitude of the primary star

SubField 5B Magnitude of the secondary star

Field 6 This optional field is the reference equinox year. It is assumed to be 2000 if absent

Field 7 This field may contain either 3 or 6 subfields (one or two triples of year/separation/position angle) or 7 subfields (orbital elements).

If 3 or 6 subfields, they define positions grouped as the following triplets:

SubField 7A/D Year of the separation and position angle given in the next two fields, decimal year or month/day/year

SubField 7B/E Separation, arc seconds

SubField 7C/F Position angle, degrees E of N, referenced to equinox in field 6

If 7 subfields, they define a true orbit:

SubField 7A Semi-major axis, arcseconds

SubField 7B Inclination from plane of sky, degrees

SubField 7C Longitude of node, degrees

SubField 7D Eccentricity

SubField 7E	Epoch of periastron, decimal year or month/day/year
SubField 7F	Argument of periastron, degrees
SubField 7G	Period. Units are designated by suffix **y** for years, **d** for days, or **h** for hours. If no designation the default is years.

If **Field 2** is **e** the object type is elliptical heliocentric (eccentricity < 1) and the remaining fields are defined as follows:

Field 3	i = inclination, degrees
Field 4	O = longitude of ascending node, degrees
Field 5	o = argument of perihelion, degrees
Field 6	a = mean distance (aka semi-major axis), AU
Field 7	n = mean daily motion, degrees per day (computed from a**3/2 if omitted)
Field 8	e = eccentricity, must be < 1
Field 9	M = mean anomaly, i.e., degrees from perihelion
Field 10	E = epoch date, i.e., time of M
	SubField 10A First date these elements are valid, optional
	SubField 10B Last date these elements are valid, optional
Field 11	D = the equinox year, i.e., time of i, O and o
Field 12	First component of magnitude model, either g from (g,k) or H from (H,G). Specify which by preceding the number with a "g" or an "H". In absence of either specifier the default is (H,G) model. See Magnitude models.
Field 13	Second component of magnitude model, either k or G
Field 14	s = angular size at 1 AU, arc seconds, optional

You may have other parameters available for elliptical orbits 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.

If **Field 2** is **h** the object type is hyperbolic heliocentric (eccentricity > 1) and the remaining fields are defined as follows:

Field 3	T = date of the epoch of perihelion
	SubField 3A First date these elements are valid, optional
	SubField 3B Last date these elements are valid, optional

Field 4	i = inclination of orbital plane to ecliptic, degrees
Field 5	O = longitude of ascending node, degrees
Field 6	o = argument of perihelion, degrees
Field 7	e = eccentricity, must be > 1
Field 8	q = perihelion distance, AU
Field 9	D = the equinox year (i.e., time of i/O/o)
Field 10	g component of magnitude model. See Magnitude models.
Field 11	k component of magnitude model
Field 12	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:

```
q = a*(e-1)
```

If **Field 2** is **p** the object type is parabolic heliocentric (eccentricity exactly equal to 1) and the remaining fields are defined as follows:

Field 3	T = date of epoch of perihelion	
	SubField 3A	First date these elements are valid, optional
	SubField 3B	Last date these elements are valid, optional
Field 4	i = inclination, degrees	
Field 5	o = argument of perihelion, degrees	
Field 6	q = perihelion distance, AU	
Field 7	O = longitude of ascending node, degrees	
Field 8	D = the equinox year (i.e., time of i/O/o).	
Field 9	g component of magnitude model. See Magnitude models.	
Field 10	k component of magnitude model	
Field 11	s = angular size at 1 AU, arc seconds, optional	

If **Field 2** is **E** (note upper case) the object type is Earth satellite and the remaining fields are defined as follows:

Field 3	Epoch of the other fields	
	SubField 3A	First date these elements are valid, optional
	SubField 3B	Last date these elements are valid, optional
Field 4	inclination, degrees	
Field 5	RA of ascending node, degrees	
Field 6	eccentricity, must be < 1	
Field 7	argument of perigee, degrees	
Field 8	mean anomaly, degrees	
Field 9	mean motion, revs/day	
Field 10	orbit decay rate, revolutions/day^2	

Field 11	integral reference orbit number at Epoch
Field 12	drag coefficient, 1/(earth radii); optional

XEphem arbitrarily assigns all Earth satellites a visual magnitude of 2.0.

XEphem can also read files directly containing the venerable Two-Line-Element (TLE) format. See next section for details.

If **Field 2** is **P** (note upper case) then **Field 1** must be the name of a built-in object for XEphem and no other fields are defined. The following names are recognized:

Sun
Moon
Mercury
Venus
Mars
- Phobos
- Deimos

Jupiter
- Io
- Europa
- Ganymede
- Callisto

Saturn
- Mimas
- Enceladus
- Tethys
- Dione
- Rhea
- Titan
- Hyperion
- Iapetus

Uranus
- Ariel
- Umbriel
- Titania
- Oberon
- Miranda

Neptune
Pluto

7.1.2.3 Magnitude models

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
`r` = comet-sun distance.

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 neither model takes into account the phase angle of sun light.

7.1.3 Notes

XEphem uses a different window to manage Field star 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 source distribution tree.

7.1.4 Two-line Earth satellite element sets

XEphem supports reading files which contain Earth satellites defined using the the NORAD "two-line element" set format, or TLE. Because the TLE format is quite rigid and includes a checksum within each line, XEphem is able to search files containing other arbitrary text and find each properly formatted TLE contained therein. Follows is a description of the TLE. Note the line immediately preceding the TLE, line "0", is assumed to contain a common name for the satellite, this line is only used if the following two lines conform to TLE.

Data for each satellite consists of three lines in the following format:

```
AAAAAAAAAAAAAAAAAAAAAA
1 NNNNNNU NNNNNAAA NNNNN.NNNNNNNN +.NNNNNNNN +NNNNN-N +NNNNN-N N NNNNN
2 NNNNN NNN.NNNN NNN.NNNN NNNNNNN NNN.NNNN NNN.NNNN NN.NNNNNNNNNNNNNN
```

Line 0 is a twenty-four character name.

Lines 1 and 2 are the standard Two-Line Orbital Element Set Format identical to that used by NORAD and NASA. The format description is:

Line 1

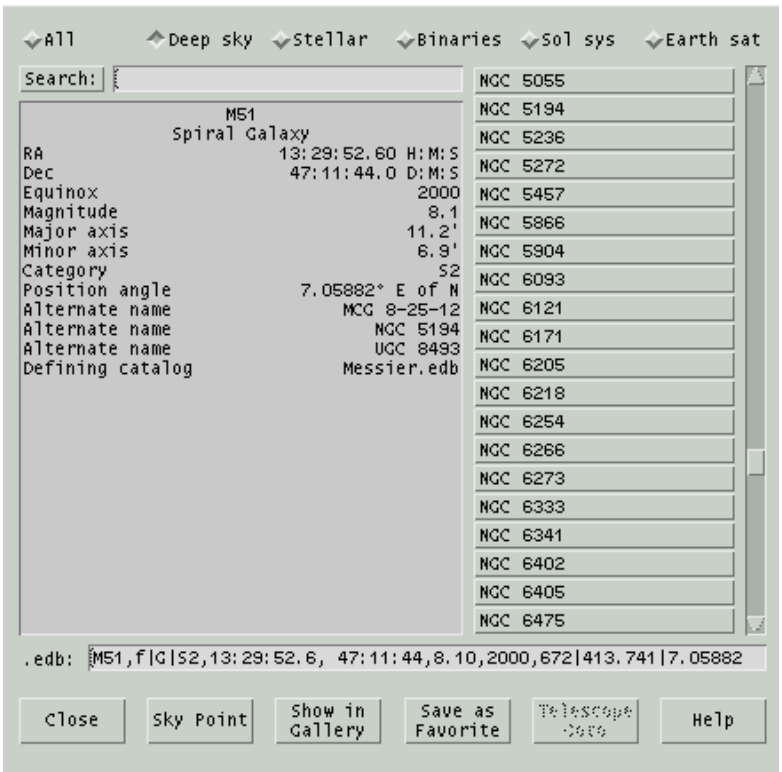
Column	Description
01	Line Number of Element Data
03-07	Satellite Number
08	Classification (U=Unclassified)
10-11	International Designator, last two digits of launch year, 2000+ if < 57.
12-14	International Designator, launch number of the year
15-17	International Designator, piece of the launch
19-20	Epoch Year, last two digits of year, 2000+ if < 57
21-32	Epoch Day of the year and fractional portion of the day
34-43	First Time Derivative of the Mean Motion

45-52	Second Time Derivative of Mean Motion (decimal point assumed)
54-61	BSTAR drag term (decimal point assumed)
63	Ephemeris type
65-68	Element number
69	Checksum (Modulo 10) (Letters, blanks, periods, plus signs = 0; minus signs = 1)

Line 2

Column	Description
01	Line Number of Element Data
03-07	Satellite Number
09-16	Inclination [Degrees]
18-25	Right Ascension of the Ascending Node [Degrees]
27-33	Eccentricity (decimal point assumed)
35-42	Argument of Perigee [Degrees]
44-51	Mean Anomaly [Degrees]
53-63	Mean Motion [Revs per day]
64-68	Revolution number at epoch [Revs]
69	Checksum (Modulo 10)

7.2 Index



This window shows a list of all objects currently loaded into memory sorted by name. Or, by chosing a toggle button across the top, the list can be restricted to just deep sky, stellar, binary systems, solar system and Earth satellites. The list does not include Favorites.

Each object name, including all alternate names, are in the scrolled list on the right. Clicking an arrow button moves the list by one object up or down; clicking above or below the thumb control scrolls the list so that the top object moves to the bottom or *visa versa*. Clicking on an object displays its defining parameters in the box to the left, and also displays its .edb file format entry in the read-only text field below.

The list of objects may be searched by entering a glob pattern in the **Search** field then typing Enter or clicking Search. If more than one object name matches, clicking Search again scrolls to the next candidate; the search wraps back to the front when no more are found.

Buttons across the bottom function as follows:

Sky Point

This will mark the object currently selected in the Sky View, repointing if necessary to move it into the field of view.

Show in Gallery

If this object is in the Gallery, this button will be available and will display the object.

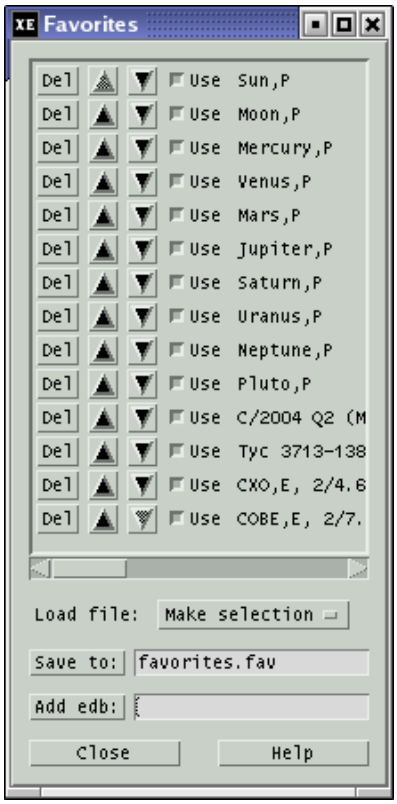
Save as Favorite

This button will add the object currently selected to the list of Favorites.

Tel Goto

This will send the object currently selected to the Telescope control system. Whether this button is active depends on the state of the telescope control subsystem when the Index window was opened. If the button state is incorrect, close and reopen the Index window.

7.3 Favorites



This window allows you to add, arrange, remove and temporarily deactivate an arbitrary collection of XEphem objects, called Favorites. Once defined as a Favorite, the object remains available whether or not its original database file is currently loaded.

Favorites have special significance in several places throughout XEphem. For example the rows in the Data Table and in the Night at a Glance windows are exactly those of the Favorites. The Earth view shows those Favorites which are satellites. Favorites are available very easily in the Favorites menu in the Sky View. And the Solar System view displays those Favorites that are within the solar system.

Objects may be added to the list of Favorites in several ways:

- from the `Data » Index` window by browsing the objects currently loaded in memory then clicking **Favorite**;
- from buttons labeled **Favorite** located in several dialogs throughout XEphem;
- from buttons in the popup menus of several views when clicked over displayed objects; and
- by entering its .edb format definition in the text field near the bottom and clicking **Add edb**.

Each entry in the Favorites list shows its complete .edb format definition. Each entry has the following controls:

Del

removes the entry from the Favorites list

Up and Down arrow buttons

move the entry up and down to arrange the Favorites into any designed order. This is useful where Favorites define rows such as in the Data Table and Night at a Glance windows.

Use

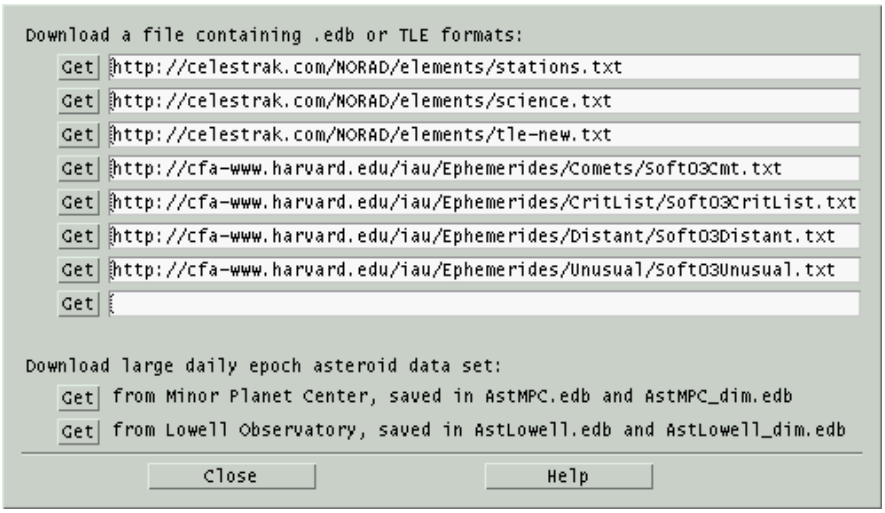
specifies whether to use or hide the entry from the rest of XEphem without actually Deleting

it.

The buttons across the bottom allow you to **Save** the current set of Favorites to a file and later **Load** them again. The suffix of these files must be **.fav** and will be added automatically if not included in the file named in the text field. When XEphem first starts, it automatically loads the file named in the Save text field. To save this file name, go to `Preferences » Save` and Save the XEphem*Favorites*File resource under the Favorites category.

7.4 Download

This window provides an easy means to download from the Internet to disk and simultaneously load into memory 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. The file is saved in the Private directory, converted to .edb format if it is not already.



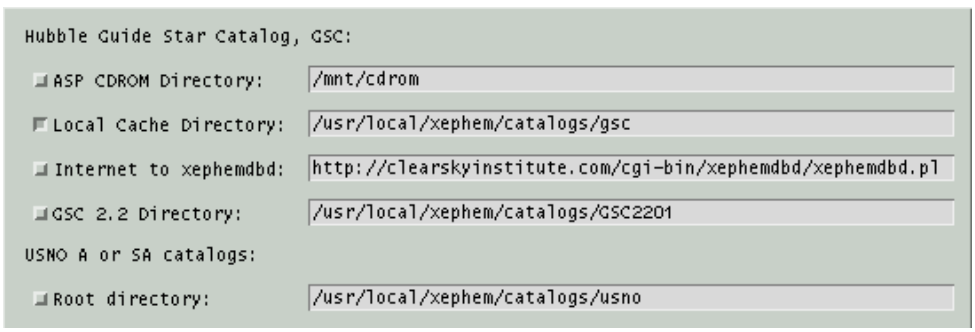
Several particularly useful sites as of this build are already entered. The first three are from Dr. TS Kelso's Earth satellite lists at celestrak.com. The other four are the Minor Planet Center's lists of hot comets and unusual asteroids specially formatted for XEphem. Click **Get** beside the desired catalog to download the file to the Private directory and simultaneously load into XEphem memory.

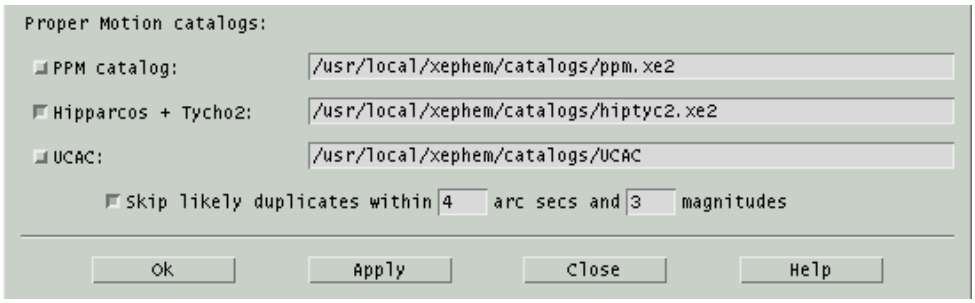
Special files created by the Minor Planet Center and Lowell Observatory may also be downloaded. Each organization maintains extensive lists of all known asteroids and produces on a regular basis Keplarian orbital elements precessed to the current date. Both are of excellent quality. When the **Get** 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. All files are created in the user's Private XEphem directory. The real work is performed by two perl scripts, mpcorb.pl and astorb.pl, respectively. These may be run independently of XEphem if desired.

7.5 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 » Files` window nor are they available for searching or inspection using the `Data » Index` window. This results in little loss of generality, however, since (once found!) they may be assigned to the user Favorites.

The controls in the Field Stars setup window are grouped into categories, depending on the basic source of the stars, as follows:

7.5.1 Hubble GSC

The Hubble Guide Star Catalog is a 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.

ASP CDROM Directory

This choice enables reading field stars from the Hubble Guide Star Catalog made available some years ago 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 any entire CDROM segment at once if desired. These files are already included in te commercial version of XEphem.

Internet to xephemdbd

This choice is to use the Internet to access an XEphem GSC server. To use this source, select this option and type the URL to the remote xephemdbd.pl in the text field provided.

GSC 2.2 Directory

This choice enables using a local copy of the GSC 2.2.0.1 catalog in xe3 format. This catalog only contains stars between magnitude 10 and 18.5, so it must be used in conjunction with an additional catalog for completeness. The Hipparcos catalog is an ideal companion and so is also automatically chosen as a convenience.

7.5.2 USNO A or SA catalogs

Root directory

This choice of field stars supports the SA and 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. 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.

7.5.3 Proper Motion catalogs

These large catalogs include information regarding proper motion. 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 here 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. 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.

UCAC

> This choice allows using the USNO Astrographic catalog with XEphem. For more information on this catalog please refer to http://ad.usno.navy.mil/ucac.

7.5.4 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 the given number of arcseconds and their brightnesses differ by less than the given number of magnitudes. (The generous default 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.

7.5.5 Notes

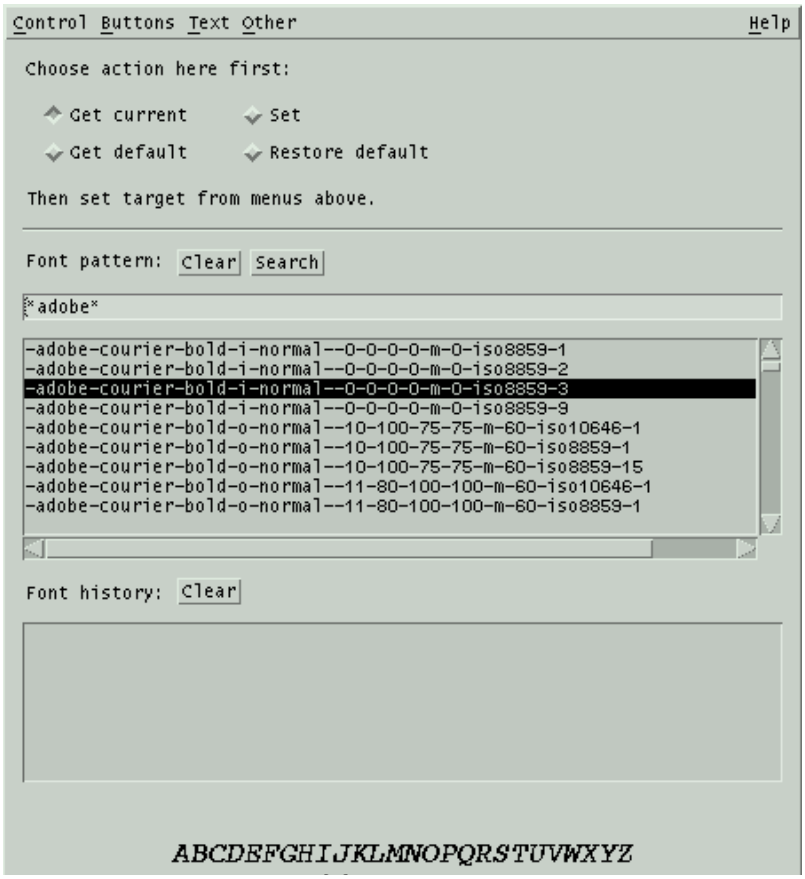
If at any time something goes wrong during the acquisition of any Field Stars from any View, the responsible option in that view is also turned off automatically. The problem should be corrected and Field stars turned on again.

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 except USNO are limited to 30 degrees; USNO are limited to 15 degrees; network queries impose various limits.

8.0 Preferences

The simple choice preferences are covered in the Main Window section. See Preferences menu,

8.1 Fonts

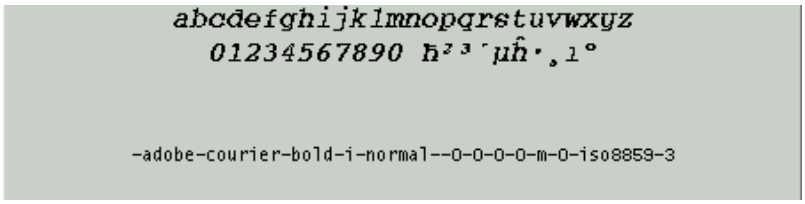


This window lets you change most of the fonts used by XEphem. The basic technique is to specify a font, use the four toggle buttons to choose which action to take then perform the action in a particular font context by clicking in the menus accessed from the menubar across the top.

To browse the available fonts, type a pattern in the field provided and click **Search**. This will display the names of all fonts matching a pattern. To see all available fonts, use the wild card pattern of a single star (*). To be more specific, specify the fields desired and fill the gaps between with the star wildcard. See the next section for a description of each field.

Clicking a font in the top list will display a sample and its

full name in the region at the bottom.



The **Buttons, Text** and **Other** 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 (when opened or after you do a Refresh). This allows you to Save the new fonts set here 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.

8.1.1 XLFD

The font names are in the format called X Logical Font Description. There are 15 fields separated by hyphens. The fields are as follows:

Foundry

The organization that digitized the font data.

Family

The commercial name of the font.

Weight

The relative weight of the font, such as bold, medium or regular.

Slant

A code indicating the slant:

r Roman (no slant)

i Italic (slant left)
o Oblique (slant left)

Set Width

The width with respect to what the foundry considered normal. Choices include normal, condensed, narrow, double.

Additional Style

Anything else needed to uniquely identify the font, such as sans or serif.

Pixel Size

The height of an *em* in pixels.

Point Size

The height of an *em* in tenths of a point, where one point is 1/72 inch.

Horizontal Resolution
Vertical Resolutoin

The resolution of the device for which the font was designed, in pixels-per-inch.

Spacing

A code indicating the spacing between characters in the font:

M Monospaced (fixed pitch)
P Proportional spaced (variable pitch)
C Character cell (each character occupies the same size box)

Average Width

Average width of all characters in the font, measured in tenths of a pixel.

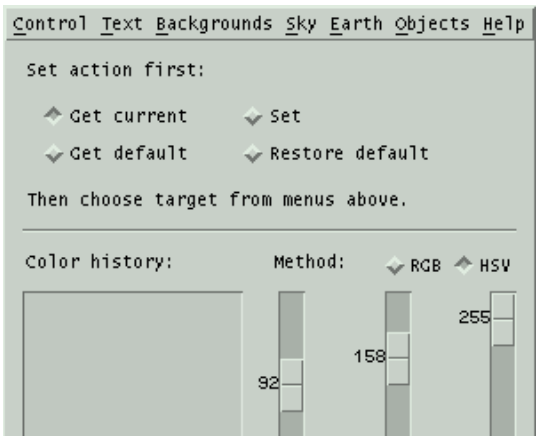
Registry
Enoding

The registration authority and their name for the character set from which the characters in the font are drawn. For example ISO8859-1, also known as Latin-1.

Scalable fonts are indicated by 0 for point size, pixel size, x and y resolution and average width (fields 7, 8, 9, 10 and 12). To choose a specific scalable font, specify desired values for some but not all of these fields, letting the system fill in the others.

8.2 Colors

This window lets you change most of the colors used by XEphem. The basic technique is to use the four toggle buttons to choose which action to take then perform the action in a particular color context by clicking in the menus accessed from the menubar across the top.

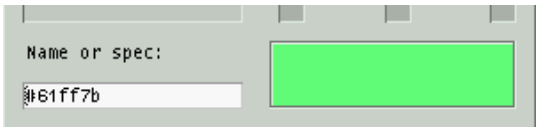


The possible actions are as follows:

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. Each scale ranges from 0 through 255. Hue is the basic spectral color, where 0 is red, 85 is green, 170 is blue. 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.

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.

8.2.1 Colors Control menu

Night mode

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 whether or not they are new in the Save window.

Grab color

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.

Clear history

Erases all entries in the History list.

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 (when opened or after you do a Refresh). This allows you to Save the new color choice permanently. If you do not Save it, the change only effects XEphem until you exit.

8.2.2 Star colors

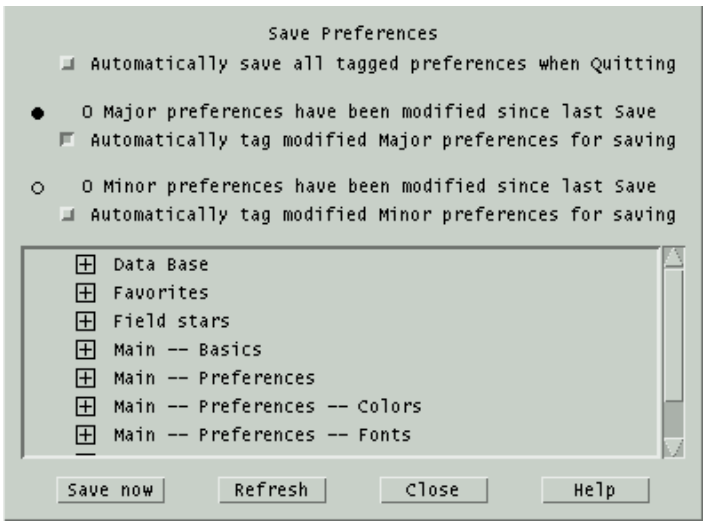
XEphem assigns colors to stars based on their spectral classification. The default colors were chosen based on work done by Mitchell Charity. The colors are specified using X Resources. The resource names each begin with "XEphem.starSpect" followed by one or two characters. The value of the resource is the color. The following table shows the default spectral color resources built into XEphem:

XEphem Resource Name	Default Color Value
XEphem.starSpectO	#9bb0ff
XEphem.starSpectB	#aabfff
XEphem.starSpectA	#cad7ff
XEphem.starSpectF	#f8f7ff
XEphem.starSpectG	#fff4ea
XEphem.starSpectK	#ffd2a1
XEphem.starSpectM	#ffcc6f
XEphem.starSpectN	#ff8f2c
XEphem.starSpectS	#ffc574
XEphem.starSpectC	#ff9e40
XEphem.starSpectT	#ffd19a
XEphem.starSpectW	#c4c4ff

XEphem uses the closest entry with matching first character. If no entry is found with matching first character then white is used and a message is added to the System log. The spectral color resource values may be edited or additional resources can be added but this must be done by hand, there is no GUI support available. Always edit the XEphem resource file while XEphem is *not running* to avoid any chance of conflict.

8.3 Save

This window displays all of the options, settings and controls, collectively called Preferences, throughout XEphem that may be saved and reinstated next time the program is started. XEphem has many such preferences, so they are separated into categories in this window for easier management. Each category may be expanded or collapsed using the +/- toggle square to show each individual preference.



Preferences are saved using the standard Resource mechanism provided by the X Window System. These resources are saved in the file **XEphem** located in the Private directory.

Each preference may be tagged for saving. The toggle at the top controls whether all tagged preferences will be **Autoatically save**d when XEphem is Quit.

Preferences have been divided into two classes.

Major: In the opinion of the author these preferences are sufficiently interesting that they are likely to be worth saving and automatically restoring between one invocation of XEphem and the next.

Minor: Everything else, presumably less critical in nature. It is expected that you are likely to change these preferences frequently in due course while operating XEphem yet they do not cause

major effects on program behavior so saving them at any one particular setting is not especially compelling. Minor preferences are things like window size and position, scale settings which only effect views, and all of the Sky View Filter and Option settings.

This distinction is of course rather arbitrary so please take care when changing and saving preferences so the ones you want are saved.

The number of preferences in each class currently tagged for saving is indicated by messages near the top.

The scrolled area can display each preference, whether it is tagged for saving and the ability to change whether it is tagged. Each category of preference can be expanded for more detail using the +/- toggle square.

In the expanded view, each preference and its value are shown exactly as it will appear in the disk file if Saved. Those preferences 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. Major preferences are marked with a solid bullet, Minor preferences with an hollow bullet. A toggle next to each preference allows individual selection over whether the preference will be written to disk on the next Save. After each Refresh, the toggles are set for those preferences found to have changed since the last Save if their class is set to be automatically tagged. Each toggle may be changed manually in either direction to override this automatic behavior on an individual basis if desired but not these will be overridden with the next Refresh.

In the collapsed view, if at least one Major preference is out of date in a category, a solid bullet is placed next to the category heading; otherwise if at least one Minor preference is out of date a hollow bullet is used.

Note that the information in this window does *not* automatically track changes in preferences as XEphem is used. You must use Refresh to update the status manually 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.

Save now

Write each tagged preference to disk to the XEphem resource file. If the file already exists, it will first be copied to XEphem.bak in the same directory. If a preference 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 preferences will be considered up to date, even if they were not selected to be written to the preference 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

Update the changed and save status of each preference. This refresh action also happens automatically *after* a Save is performed and just before XEphem quits when deciding which preferences to save if the Automatic saving option is enabled.

9.0 Multifunction Tools

The tools in this section are used in several different places throughout XEphem. The descriptions here are generic. If there are any special issues when used in certain contexts they will be described in the appropriate sections elsewhere.

9.1 Trails

This window allows you to define a set

of time values spaced at regular intervals before and after 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.

Six format parameters must be specified:

Orientation

This choice determines where the stamps appear in relation to their corresponding position mark. The first several options should be self-explanatory. 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 time 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 several predefined intervals 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 labeled with a time stamp. Choose from among several options or choose None if no labeling is desired. Times will be printed surrounded by parentheses if the object is an Earth satellite and it is eclipsed.

Format

This choice determines the format in which to display each time-stamp. Choose Hour:Minute with or without Seconds or the date formatted as per the `Preferences » Date formats` option in the Main menubar, see Preferences.

Font

This choice sets the size of the annotation text font.

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. 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 for special situations.

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.

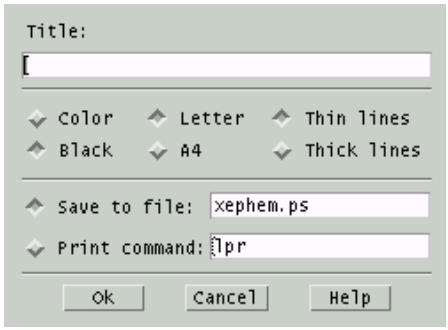
Two scales near the bottom specify the number of tick marks to create before and after the starting time.

Once the choices are set up as desired, **Ok** will create the trail and the window will disappear. **Apply** will create the trail but the window will remain up for further use. **Close** just dismisses the window without creating a trail.

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 windows 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.

The settings for each view context may be saved using `Preferences » Save`.

9.2 Printing



This window lets you print the current view or save it to a file. In either case the format used is Postscript.

Title

If you enter a string in the text field labeled Title, the string will be printed centered across the top of the page.

Color
Black

The top left pair of toggle buttons allow you to choose whether color commands will be included in the Postscript generated.

Letter
A4

The center pair offer the choice of US Letter size 8½x11" with ¾" margin or ISO A4 210x297mm with 15mm margin.

Thin lines
Thick lines

The right pair offer the choice of drawing with very thin lines or somewhat thicker lines.

Save to file

If you choose to Save to a file, turn on that toggle button and enter the desired file name in the text box to the right of the toggle button. Unless begun with a / the file name is in the Private directory.

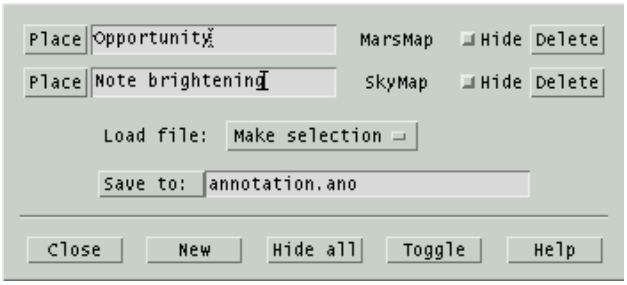
Print command

If you choose to print directly to the printer, turn on that toggle button and enter 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. You can also enter a command here that will display the file, such as gv to preview the file then and print from there.

When ready, click **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.

9.3 Annotation

This window allows you to add your own text and lines to any graphical view. Annotation locations are saved in the world coordinates of the view. For example, in the Earth view they are saved in Lat and Long. In the Sky View, they are saved in the current display mode, that is, either RA/Dec or Alt/Az. The window shows which view each annotation refers to.



You may **Save** the current set of annotations to the specified file or **Load** a set by selecting from the files presented in the pop-down menu. Annotation files use the suffix .ano. XEphem tries to automatically load the file specified in the Save field when it starts. This file name can be saved in the `Preferences » Save` window in the Annotation section.

To add a new annotation entry:

1. click **New** to create a blank entry,
2. type in the desired text,
3. click **Place** to begin the placement procedure,
4. move the cursor to position the text where desired,
5. click and hold to anchor the text and begin drawing a line,
6. move the pencil cursor to position the far end of the line as desired,
7. release.

To move an existing entry, click **Place** again and proceed as above with step 4.

To draw just a line with no text, leave the text field blank.

To place text with no line, immediately release after anchoring the text.

To change just the text of an existing entry, edit the text and type Enter.

To temporarily hide one entry, click **Hide** on its line. To hide all entries click **Hide all**, to toggle which entries are hidden click **Toggle**.

To delete an entry, click **Delete.**

10.0 Credits

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Milky Way contour by Pertti Paakkonen, ppaakko@cc.joensuu.fi, in turn based on map from http://www.ebicom.net/~rsf1/fun/sm-new.htm copyright (c) 1972,2001, R.S. Fritzius, may be reproduced for non-commercial purpose.

The local magnetic declination model is from the DoD World Magnetic Model as published at http://www.ngdc.noaa.gov/seg/potfld/DoDWMM.shtml

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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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Martian relief map completed June 2000 using data from Mars Orbiter Laser Altimeter on board the Mars Global Surveyor, operated by the Jet Propulsion Laboratory, NASA. See http://marsprogram.jpl.nasa.gov/mgs

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

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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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Images of Saturn from STScI.

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

1. "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
2. "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.

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Rotated trail text uses the xvertext package. Here is the copyright:

> xvertext 5.0, Copyright (c) 1993 Alan Richardson (mppa3@uk.ac.sussex.syma)
>
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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. Before 3.6 the figures were the work of Chris Marriot. 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 following notice:

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The Earth shaded elevation relief map shipped with XEphem 3.6 is from the National Geophysical Data Center.

The pulsar and Radio databases are based on lists supplied by Robert Payne, rpayne@nrao.edu. Errors in converting to XEphem are mine.

The lunar image is based on one I found surfing at: ftp://seds.lpl.arizona.edu /pub/images/planets/moon/fullmoon.gif. The calculations for the longitude of the terminator and the solar altitude are based on the program colong.bas by David Bruning and Richard Talcott, published in _Astronomy_, October 1995, page 76.

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Many of the sample cities in the "xephem_sites" file are from the xsat program, which included the following notice:

Most of the sample observatories in the "xephem_sites" 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 their huge lists of asteroids. See ftp://ftp.lowell.edu/pub/elgb/astorb.html and http://cfa-www.harvard.edu/cfa/ps/mpc.html , respectively.

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I wish to thank all the organizations behind the incredible Internet for its maintenance and free and easy access. I also wish to express my hope that it retains the spirit of cordial cooperation it fostered in its formative years.

I learned most of what I know of X Windows and Motif programming from ICS courses and material found in the various excellent texts from O'Reilly & Associates, Inc.

Thanks to MIT and the X Consortium for inventing, championing and maintaining the X Window system, and the various contributing organizations to the Open Software Foundation for Motif. Their vision of network-aware graphics is still unmatched.

Similarly, I will be forever indebted to all who contributed to UNIX. My passion and appreciation for this remarkable operating system matured while I enjoyed four wonderful years at Kitt Peak National Observatory (now the National Optical Astronomical Observatory), Tucson, AZ, in the early 80's. As with X, UNIX plays a central role in my enjoyment of a career in scientific computing.

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Special thanks to all the folks over the years who have provided innumerable ideas, suggestions and bug reports, both for XEphem and its ancestor, ephem. A major benefit to writing and distributing these programs has been the chance to make many friends from around the world.

Elwood Downey ecdowney@ClearSkyInstitute.com

11.0 Notes

11.1 Horizon

XEphem uses a horizontal plane tangent to the Earth at 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 just 5 feet.

11.2 glob Patterns

Some of the searches in XEphem can be performed using glob patterns. The term glob refers to a limited form of pattern matching (limited with respect to the more capable "regular expression") historically originating in the UNIX shells for the purposes of specifying a collection of file names. In XEphem the glob patterns are implemented using the fnmatch() POSIX function. On GNU systems the flag FNM_CASEFOLD is used which makes the pattern case insensitive. A glob pattern is set of normal text characters interspersed with any of the following special characters known as wildcards:

glob wildcard	Meaning
?	matches exactly one character
*	matches zero or more characters
[abc]	matches any one of the specified characters. A pair of characters separated by a hyphen denotes a range expression such that any character that sorts between those two characters, inclusive, is matched. If the first character following the [is a ! or a ^ then any character *not* enclosed is matched.

For example, if a list of candidates consists of the following:

abc
aabc
abbc
acc
adc

then the pattern a* matches all; ab* matches abc and abbc; a[ac]* matches aabc and abbc; a?c matches abc, acc and adc; a[a-c]c matches abc and acc; a[^a-c]c matches adc; and *b* matches abc, aabc and abbc.

11.3 Accuracy

In the period 1689 through 2247 Jupiter and beyond use CHAPRONT J., Astron. Astrophys. Suppl. Ser. 109, 181 (1995), otherwise all planetary ephemerides except Pluto use VSOP87 from Bretagnon P., Francou G., Astron. Astrophys. 202, 309 (1988). Compared with JPL DE200 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.

Lunar ephemerides are from S. L. Moshier, December, 1996, available from ftp://ftp.std.com/pub/astronomy/selenog.zip. Compared with JPL DE404 the accuracy is better than 0.5" for the period -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 within about 0.1 degree.

The natural satellite model from BDL used for 1999-2010 is stated as good to 1/2 arcsecond accuracy. In my tests against JPL DE405 I would say this is true about 50% of the time, with a worst case of about 4 AS.

11.4 TODO

The following is the current list of future 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.
- display occultation path between *any* two objects in the Earth 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
- option for rise/set info to be Today or Next.
- add "Plot JD as date" to plot display
- use better earth shape model
- add T » F and F » T to Binary
- use user-defined horizon for rise/set calculations
- way to repeat the Solver for more solutions, as in "solver in a loop"
- expand .edb to capture real variables
- more hot-keys
- month of lunar phases
- Jup and Sat moon timelines and events, ala S&T
- separate Telescope view window
- connect trails with spline not just line segments
- direct connections to Simbad and NED
- plot in polar coords
- automatic initial Go
- topocentric lunations
- individual control over trails in sol system
- provide a means to save and install multiple color+font schemes.
- tool to generate MPC astrometric report
- draggable eyepieces

11.5 Known Bugs

- Preferences » Time Zone does not update dates of FM/NM if they happen to squirm.
- 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
- plot's View settings are not Saveable.
- figure out calendar prior to Oct 1752.
- Sky View trails are not always clipped properly against a user-defined horizon
- The visual magnitudes for all solar system bodies except the planets do not take into account the phase.
- Changing equinox or geo/topo then update, moon view tables do not update.
- Time not correct when system set to POSIX time
- Earth satellites are not plotted in Sky View correctly in geocentric&altaz mode (use geocentric&radec mode).

11.6 History

In 1981 I purchased a genuine IBM PC. Soon I was building a character oriented program in C for DOS that displayed ephemeris data, packing as much as possible on the character-based 24x80 display. That program was called *ephem* because it was as much of the word *ephemeris* that would fit in 8 characters and still retain some sensible meaning. I was using UNIX at work so I made sure it would run there too using the *curses* library. In 1989 I took a course in Motif. By 1990 it seemed to have won the UNIX desktop wars so I started converting *ephem* to Motif+UNIX. The convention for naming X Window System programs was to add an *x* prefix so that program was named *xephem*. I have been diddling with it ever since. The original *ephem* is still available.