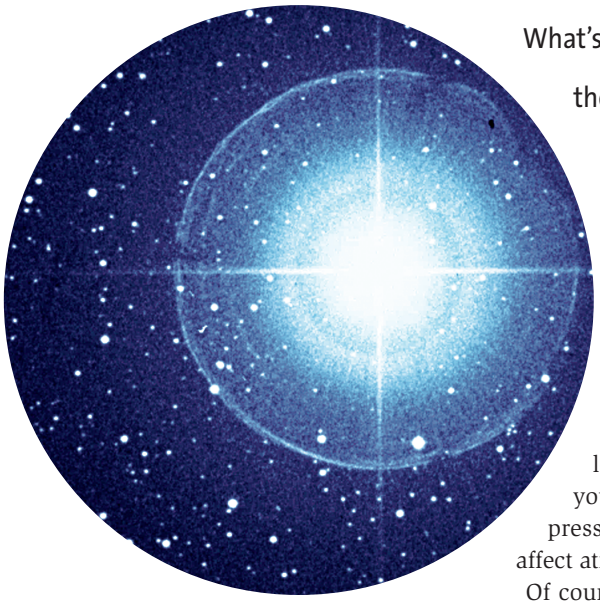
XEphem 3.5.2

Sun, Moon & Stars



What's that bright star up there called? Is that spot of light moving over there a plane or a satellite? XEphem (pronounced: "ex-eff-em") provides answers to these and (many) more questions. XEphem's development history started in 1990 with versions for various UNIX Systems, MacOS X, and even Windows. We will be looking at the current 3.5.2 version. BY MICHAEL GOTTWALD

XEphem comes from the **C**lear **S**ky **I**nstitute [1] in the USA, which was founded in 1993 to develop technologies for remotely controlling observatories. You can download the *xephem-3.5.2.tar.gz* package from CSI's homepage (see the "Installation Notes" box), or purchase a fully featured CD-ROM version.

After installing the program, budding astronomers are presented with the main window that allows you to set some basic preferences for the observatory environment.

The environment is actually your position on our planet, which can be selected from an extensive list (of towns or observatories, for example), or entered manually (by supplying the longitude, latitude and altitude above sea level). For more precise results you can also supply the local air pressure and temperature; this will affect atmospheric refraction.

Of course the observation time is also important for accurate calculations; the time, date and timezone (TZ) should be configured.

The other time parameters are defaults: XEphem offers settings such as dusk or UTC, but you can also specify special dates, such as Sidereal or Delta-T.

Users are not restricted to dates after 4713 BC (0 in the Julian calendar) as is typically the case. In fact, you can enter negative Julian dates to travel hundreds of thousands of years back in time. This is ok with respect to **precession**, but the planetary positions may be imprecise due to a lack of compensation for interference between planets in these epochs.

Of course an animated or timescale mode is important to allow program windows to come to life. This allows you to watch the planets rotate about the sun or the stars fly through the night sky. These controls are located in the lower right part of the window. The menu in the main window provides access to other windows and dialog boxes. Before we look into these, lets first take a look at the data material and star charts available for XEphem.

The Stars Like Dust

By default XEphem is supplied with the YBS catalogue (**Y**ale **B**right **S**tars) that contains only 3141 stars – which approximately corresponds to the stars visible to the naked eye. There are three ways to conjure up more stars on your screen: you can download their data from the Internet, use CD-ROMs or access the required data online.

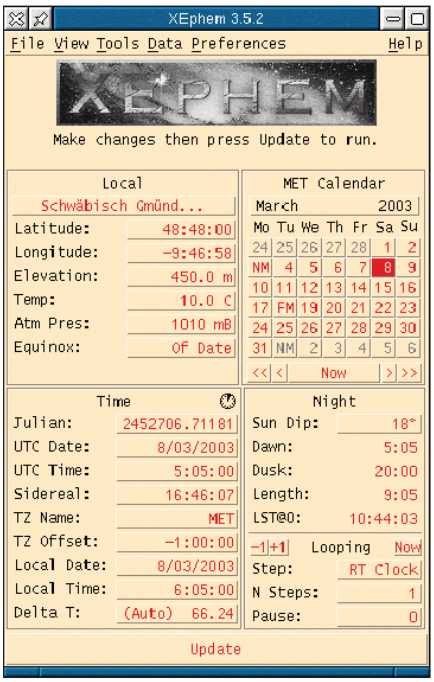


Figure 1: The main window after launching the program

THE AUTHOR

Michael Gottwald has been writing reviews on astronomy programs for Amiga Computer-magazine in the early 90's. About a year ago he migrated from the Amiga to the Linux community and has been an avid Linux user ever since.

GLOSSARY

Precession: *Like a rotating toy top, the earth's axis moves through a precession caused by the attractive force of the other planets about every 28,000 years. This causes the stellar constellations to appear to move.*

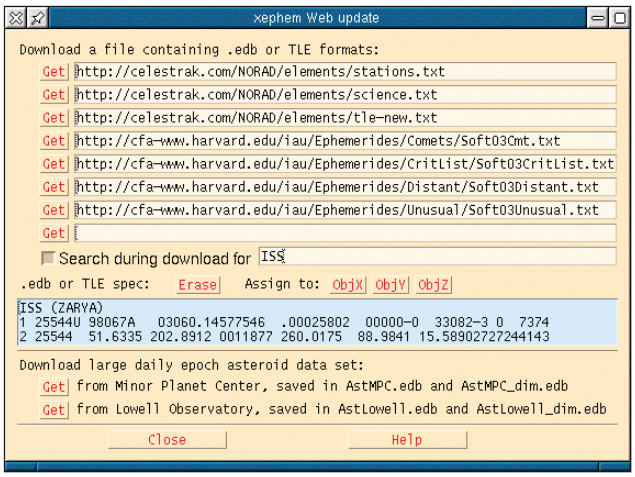


Figure 2: Internet update and online access to external stellar catalogs

A number of sites on the Internet offer downloadable XEphem catalogs [2]. These catalogs are in the program's proprietary format and end with the *.edb* suffix. You can easily convert other catalogs using tools like *cat2edb* [3].

XEphem can handle different types of stellar catalogs, such as so-called proper motion catalogs, which are tables of positions, motion, luminosity, and so on.

The PPM catalog (**P**ositions and **P**roper **M**otions) issued by the Astronomisches Rechen-Institut Heidelberg [4] contains 468,586 stars, and the combined TYCHO-2 and HIPPARCOS catalogs (2.5 million stars) issued by the European Southern Observatory [5] are well-known examples.

So-called field stars catalogs contain only digitized images of the stellar sky and thus provide only positioning and luminosity data.

The classic catalog has to be the Hubble GSC (**G**uide **S**tar **C**atalog) with over 15 million stars. This catalog is used to position the Hubble Space Telescope and is now the standard catalog for commercial astronomy programs.

The US Naval Observatory A catalog [6] provides an even larger database with 54 million stars – this corresponds to about 325 stars in an area the size of the full moon. Finally, XEphem also supports the Digitized Sky Survey (DSS) [7] of the Space Telescope Science Institute (STScI) and the European Southern Observatory (ESO). Special functions are provided for detailed analysis of these catalogs. The digital portions of the stellar sky are downloaded online from servers. This mandatory feature of DSS is optionally available for the Guide Star Catalog (GSC) [8], if you do not have the CD-ROM.

Besides individual stars, so-called deep sky objects also play an important role: these are gaseous and dust nebulae, star clusters and galaxies. Only the Messier catalog (with 106 objects) [9] provides them.

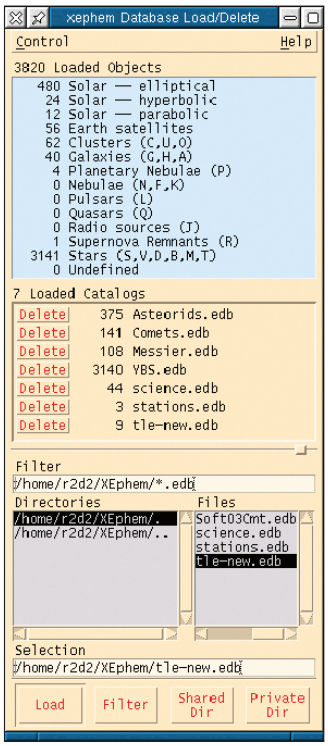


Figure 3: Database with local data

Let's leave the endless depths of the universe and return to our cosmic home. After all, it is interesting to be able to identify the planets, asteroids and comets in our solar system in the night sky, or to know in advance when a good view of Mars will be available. With the exception of the nine major planets and their moons, XEphem's own data resources do not provide any objects here, but you can use your Internet connection to perform an update to obtain the missing data (see Figure 2). The Minor Planet Center [10] provides up-to-date information on minor planets.

If this is too much effort for you, you can always purchase XEphem on CD-ROM. For a mere 59.95 dollars you will then receive no less than 14 stellar catalogs, eleven deep sky catalogs, two catalogs for minor planets and comets, and one for satellites. The manual (which is available online as a PDF document) but this costs another US $12.95. The XEphem website provides more information on this subject.

To New Windows

The five menus in the main window allow you to set various preferences or provide access to other windows. You can however, only launch one instance of each window type, for example, you can only launch one stellar sky window. If you have enabled a time control, it will apply to any windows you have opened. The window elements, such as colors and fonts can be configured individually by the user. Quick help is available for most elements, and every window has one or more help pages. This is normally all you need to get by – the manual is only required on rare occasions.

The *Data* menu is the place to load missing data. You can individually add or remove catalogs for stars, minor planets and comets. This allows you to specify the number of minor planets to display in the Solar System view, as you may otherwise discover that you can't see the wood for trees (or in this case dots) in the *Solar System* window. Figure 3 shows you the options for selecting local databases.

The *Data* menu also contains one other interesting function: *Search and ObjXYZ* (see Figure 4). This allows you to display, manipulate, highlight or center all the objects listed on the right,

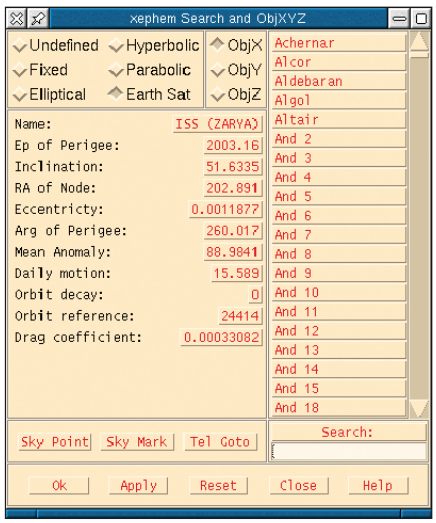


Figure 4: Memory search for an object

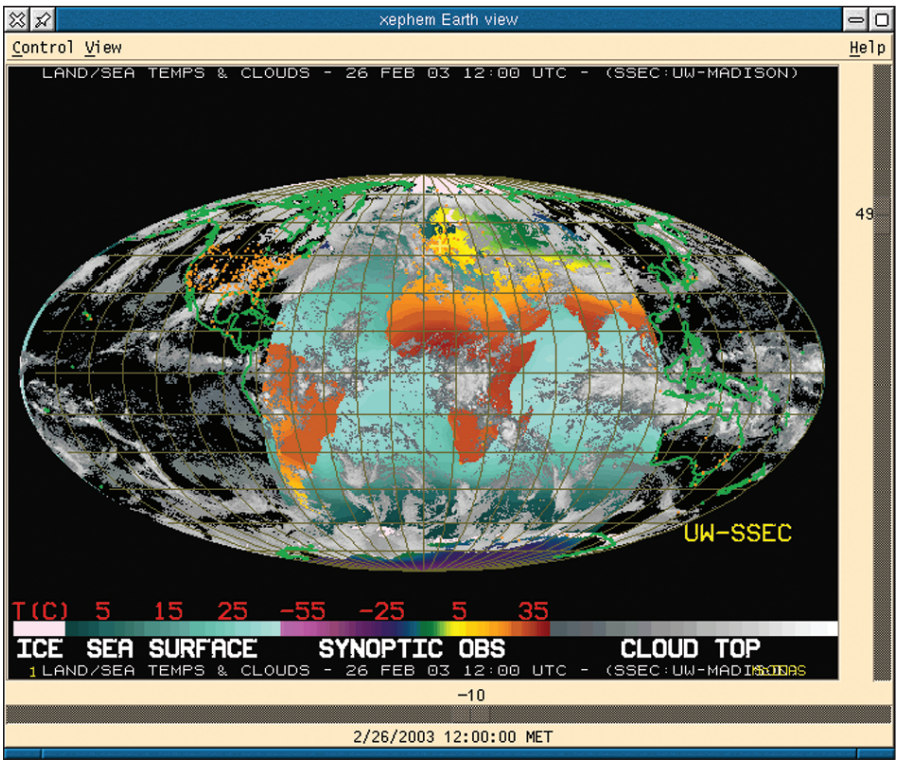


Figure 5: The earth with a current weather chart

from terrestrial satellites through to globular star clusters in the "Sky-view" window. If you have attached a telescope (such as the Meade LX200) with a GOTO control to your serial port, you can click on *Tel Goto* to align the telescope with the desired object. You can also use a search string to locate the object in your machine's memory.

A View from Space

The *View* menu allows you to display the Sky View, our Solar System or one of six planets in a window of its own, complete with menus and icons. The moon, Mars and Jupiter have a realistic surface texture and you can display additional features (craters etc.) or landing sites (Apollo on the moon, Pathfinder on Mars, etc.) if required. Planet moons are available, as is a background of stars (with "Field Stars" only) – you can enable or disable these features as required.

There is another special function for the earth (unfortunately only the contours of the earth are displayed): you can apply the current weather chart to the globe by connecting to the Space Science and Engineering Center at the University of Wisconsin (see Figure 5).

Additionally, you can project a maximum of three objects onto the globe, for example, the position of a satellite or the moon, and trace their progress for a specific time period. This would allow you to plot the path of the core shadow on the earth during a solar eclipse.

Looking into Space

The "Sky View" window provides a configurable view of the sky. In addition to the menus there are several icons and sliders located around the window content. The night sky is first shown as a projected globe with labels and titles. In this case, the observer takes up a position within a hemisphere; stars and other objects are projected onto the inner surface of the hemisphere. The field of view is always 180° and thus loosely corresponds to a fish-eye view.

Displaying a three dimensional concave sphere on a two dimensional screen obviously means that some distortion will occur. The alternative projection form is a cylinder, that is, the celestial sphere is projected onto the surface of the cylinder. This allows for a linear horizontal projection (if enabled), but distortion becomes apparent when you move towards the celestial poles (and most obviously so if you enable the coordinate grid). The horizon can be a red

GLOSSARY

Ecliptic: *The plane of the Solar System; the sun and planets as projected on the celestial sphere will move across this plane.*

Celestial equator: *The earth's equator as projected onto the night sky. It divides the northern and southern celestial hemispheres.*

Opposition loop: *A planet's motion is relative to the stars in the sky. If the earth overtakes Mars on its internal course, as it moves quicker, Mars will describe a loop in the sky for several months.*

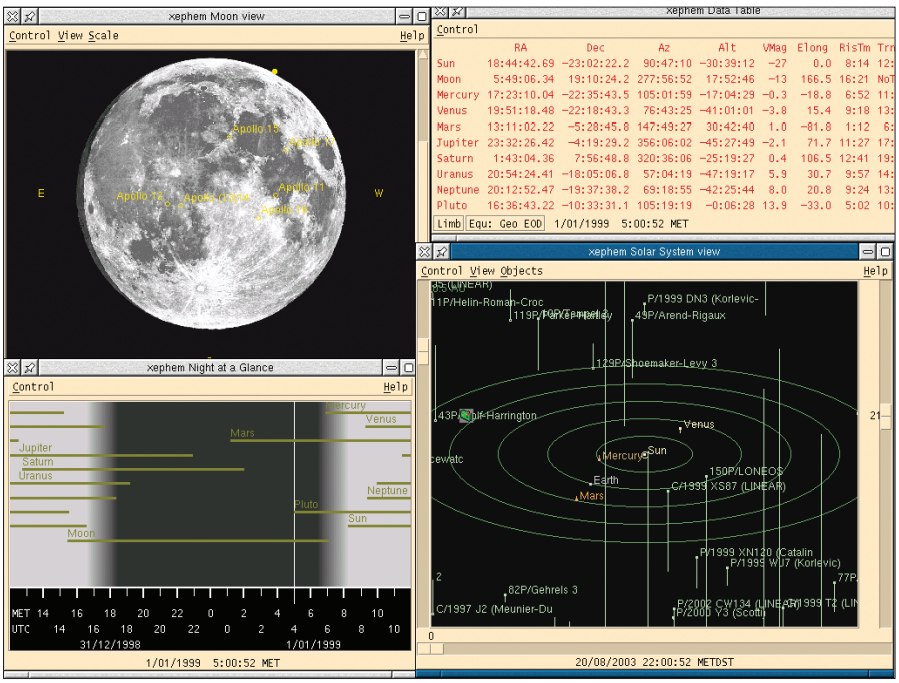


Figure 6: A selection of windows available in XEphem

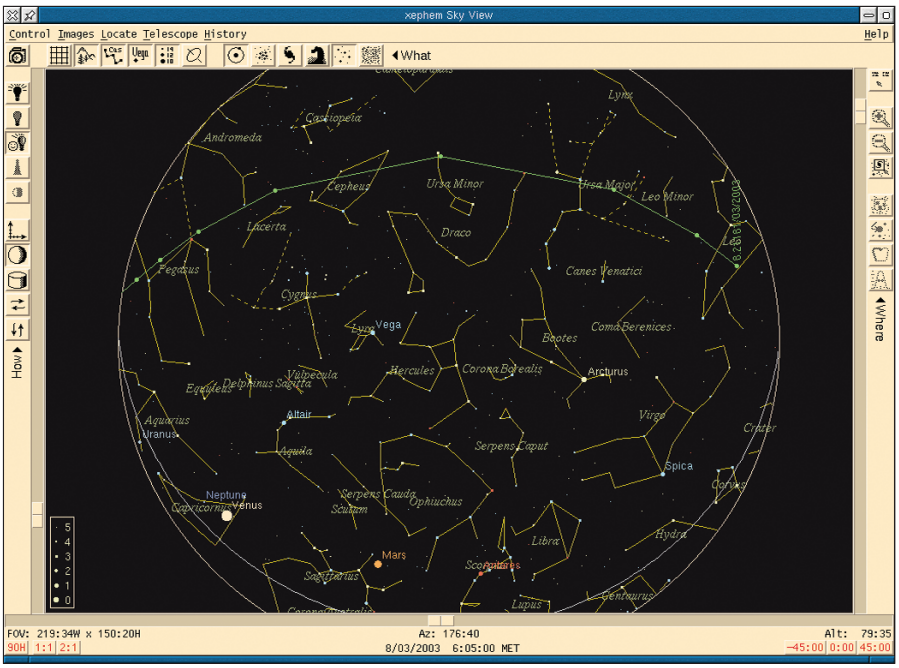


Figure 7: The ISS orbit at 6.00 am on March 8

line at altitude zero (sea level), or a landscape defined in a file; just like in real life, nothing is visible below the horizon.

The other labels provided by XEphem omit nothing that the astronomer's heart might desire, such as the **Ecliptic**, the **Celestial Equator** or a grid of celestial co-ordinates. You can draw today's boundaries for stellar constellations, highlight well-known figures, and apply Latin names or abbreviations. Stars from the YBS catalog are shown with their names (if available) or Greek letters by reference to their luminosity (Alpha being the brightest), as specified by Johannes Bayer in his stellar atlas from 1603, *Uranometria*. Other objects – planets, satellites, galaxies, nebulae, etc. can also be displayed as dots with or without labels, as required.

Three slide controls are available to enlarge or reduce the cross section of the view. Right clicking an object opens a popup with additional information, such as rising and setting times, luminosity, coordinates, etc. Additionally, right clicking provides access to menu functions that allow you to center or zoom in on an object. You can also plot the track of an object on the celestial background (for example, **Opposition loops**).

If you simply want to know if and when a planet will be visible in the night sky, it would be rather tedious to have to cycle through various views in the "Sky View" window. To avoid this the program provides a visibility diagram as one of its many useful windows (see Figure 6).

As mentioned at the start of this article, the program also supports terrestrial satellites. Of course, the International Space Station, ISS, which is currently under construction, is a good source of information. The easiest way to go is to load the current **Orbit elements** directly via the Web update function, by entering "ISS" for *Search during download for* and then clicking on *Get* in the first line of URL defaults (*stations.txt*).

You can then assign the ISS to a user-defined object using *Assign to … ObjX*. Now open the "Sky View" window and disable any labels you do not need, such as grids, galaxies, and so on. In the main window's *Data* menu, select *Search memory, define ObjX,Y,Z* to display the current ObjX – that is the ISS – in the window.

Clicking on *Sky point* will center and highlight the ISS in the "Sky View" window. Adjust the slider controls to display the ISS at the right margin. Now right click over the ISS to open the popup menu and select *Create Trail*. Enter "Now" in the *Start* box and define a *Custom* interval of 0:01 (one minute, otherwise the gaps in the orbit are too large). The *Number of tick marks* can be set to 10 and you can then click on *Ok* to plot the orbit of the ISS through the night sky (see Figure 7). The orbit elements should not be more than a few months old to avoid deviations in the plot.

Extraterrestrial

XEphem also supports *Seti@home* (Search for extraterrestrial intelligence at home) [11, 13]. The project uses radio telescopes to search for signs of intelligent extraterrestrial life. To analyze the enormous amounts of frequency data, any- one can volunteer to use their PC as an Internet based client, for as long as they like.

Installation Notes

The source code for the program is available on the CSI homepage in the form of a *tar* archive. The installation steps are comprehensively described in the accompanying text file. An RPM package is available from *www.rpmfind.net* (and on the subscription CD). You will also require the Motif development libraries [12].

INFO

[1] Clear Sky Institute: *http://www.clearskyinstitute.com/xephem/*

[2] Extra star data: *http://astro.uni-tuebingen.de/software/xephem.shtml*

[3] Conversion program: *http://www.iram.es/IRAMES/groups/astronomy/cat2edb.txt*

[4] PPM catalog: *http://www.ari.uni-heidelberg.de/*

[5] TYCHO-2 and HIPPARCOS catalogs: *http://www.eso.org/*

[6] US Naval Observatory A catalog: *http://www.usno.navy.mil/*

[7] Digitized Sky Survey: *http://archive.stsci.edu/dss/*

[8] Guide Star Catalog: *http://www-gsss.stsci.edu/gsc/GSChome.htm*

[9] Messier catalog: *http://www.seds.org/messier/*

[10] Minor Planet Center: *http://cfa-www.harvard.edu/iau/mpc.html*

[11] Seti@home: *http://setiathome.ssl.berkeley.edu/*

[12] Motif development libraries: *http://www.opengroup.org/openmotif/downloads.html*

[13] Björn Ganslandt: "Hertz Donors – Distributed Computing on Linux", Linux Magazine, Issue 25, p84