The Planets Explorer

User's Guide FOR WINDOWS

WRITTEN BY

MARIANO PEREZ & ALFONSO VILLANUEVA

Table of Contents

Chapter 1

Getting Started

Welcome

Welcome to the Planets Explorer, the perfect tool for discovering the wonders of the Solar System for the first time, or enhancing your observing pleasure and knowledge if you are already a convert to this wonderful pastime. With this book as your guide, you have at your fingertips the power to manipulate your view of the Solar System in almost any way you can imagine. You can see how the Planets or their Satellites look from any point in space, from any distance, tonight, tomorrow, or far into the past or future. You can view the stars as they appear from your own backyard, from a country on the other side of the world, or from another planet. You can witness dawn from the Moon, watch the Sun set from the surface of Mars, or even ride a Satellite. You are the master of the Solar System: you control the flow of time. You can jump instantly from one Planet to another.

You are limited only by your curiosity.

Thank you for using The Planets Explorer.

Enjoy the program!

Before You Start

This manual assumes that you possess basic computer skills such as clicking, dragging, and selecting with a mouse. You should also know how to move windows, use scroll bars, and resize windows. If you do not feel comfortable with these commands, please refer to the documentation that came with your computer.

Minimum System Requirements

For The Planets Explorer to run properly, your computer must meet the following minimum requirements:

- Windows 95/98, Me, NT, 2000 or XP
- Pentium processor or equivalent 300 MHz
- 64 Mbytes of RAM (128 Mbytes highly recommended)
- 300 Mbytes of free disk space
- 3D Graphics card with 8 Mbytes memory.

Note: When The Planets Explorer is configured to use the highest quality textures, it is very important to make sure that that the graphics card used is a high performance one, with at least 32 Mbytes RAM and GeForce 2 or equivalent 3D acceleration capacity. If you are experiencing performance problems, or the textures of some Planets are not visible, this is most likely due to a lack of processing power in your graphics card. In that case, try with lower quality texture settings.

Installing The Planets Explorer

To run The Planets Explorer, two additional programs must be installed: the Java2 Run Time Environment 1.4.0 or later, and Java3D Run Time version 1.2.1_04 or later. The installation program delivered when you purchase The Planets Explorer will install both Run Time Environments for you, together with the main application and necessary files.

To install The Planets Explorer, you need to run the setup.exe application, and follow the instructions. You will be prompted to enter information on the directory to copy the files and other data. It is strongly recommended to select the options provided by default by the setup application.

The default setup program delivered includes the Java 3D extension for DirectX. You need to have DirectX 7.0 or later installed in your computer. If you have Windows NT as operating system, you will need the openGL version, as Windos NT does not support DirectX. The openGL version of Java 3D Run Time can be downloaded for free from the site of Sun Microsystems.

Alternatively, The planets Explorer can be delivered without the Java and Java 3D Run Times. This reduces considerably the size of the setup file (helpful for Electronic Software Delivery), but requires both Run Times to be previously downloaded and installed. Here follow the steps required for such download and installation:

The first thing that needs to be installed is the Java2 Run Time Environment, version 1.4.0 or later. The corresponding executable file can be downloaded for free from Sun´s Microsystems downloads page at the following address:

http://java.sun.com/j2se/1.4/download.html

You have to choose the required run time version for Windows (USA or international).

Once the file has been downloaded, you just need to execute it and follow the instructions presented by the setup application.

After the Java2 Run Time has been installed, you need to install the Java3D extension, that can also be obtained for free in the following address:

http://java.sun.com/products/java-media/3D/index.html

please, select the runtime for the JRE format (for instance "Java 3D for Windows (DirectX version) Runtime for the JRE", version 1.2.1_04 or later. Either directX or openGL will work. If you are using Windws NT operating system, then the openGL version is mandatory, as Windows NT does not support directX. In case you are using Windows 95, Windows 98, Windows Me or Windows 2000, both openGL or directX versions can be used. Please, make sure that you have directX version 7.0 or later if you choose the directX version of Java3D Run Time.

Make sure that Java3D run time is installed in the same directory than the Java2 Run Time (this is the default option offered by the setup program).

Once the above mentioned operations have been done, The Planets Explorer can be installed by running the setup.exe application.

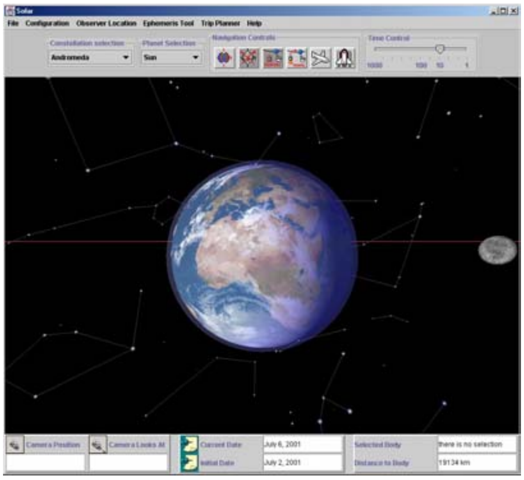
Starting The Planets Explorer

Once you have installed The Planets Explorer, you can start it by clicking the "Start" button on your desktop and then choosing Programs->The Planets Explorer.

Please, allow some time for The Planets Explorer to be loaded and initialised. Depending on the characteristics of your computer, this process might take from a few seconds to several minutes. This is due to the size of the texture files used by The Planets Explorer to represent the Solar System bodies (quasi photographic quality requires big texture files, which occupy a large amount of memory and graphics card resources.)

The Planets Explorer For the First Time

Upon starting The Planets Explorer, the main screen shows of a rotating Earth in the central 3D rendering section, as presented below:



You will immediately notice that The Planets Explorer main screen is composed by several sections, that are kept separate for the sake of clarity.

On top of the main window you find the Menus Bar. It allows you to perform typical configuration functions as well as opening the different tools provided with The Planets Explorer. See Chapter 4 for a detailed description of the Menus Bar.

Immediately below the Menus Bar you find the Tools Bar, which holds the different controls used during normal operation of The Planets Explorer such as selecting celestial objects, selecting navigation modes or manipulating time. Chapter 3 gives a throughout description of the Tools Bar.

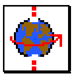
The 3D Rendering Screen occupies most of the main window area. That is where you see all the action of the Solar System happening live.

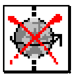
The bottom part of the main window shows the Information Bar. Several data is displayed here such as name of celestial body selected, apparent distance to selected body, current date, ... A detailed description is presented in Chapter 5.

Chapter 2

The Navigation Modes

The Planets Explorer supports three modes of Navigation through the Solar System: Teleport mode, Trip Mode and Fly mode. Each one allows you to explore the Solar System in a different way, giving total freedom of movement and selection of point of view. Additionally, you can choose to lock to the rotation of the selected body or to be independent of it. In the first case you will see the background sky rotating instead (like when we observe the sky from the Earth we see the stars rotating as we rotate with the planet). In the second case, you will see the selected Planet or Satellite rotating around its rotation axis. Clicking in the corresponding buttons in the Tools Bar activates these two modes:

 Rotate with the body

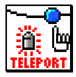
 Do not rotate with the body

The following sections explain in detail how the different navigation modes operate.

The Teleport Navigation mode

In this mode, you jump instantly to the Planet or Satellite that is selected. Upon activation of the Teleport mode, the point of observation is located at a distance of three radius from the selected body (i.e. around 20000 km in the case of the Earth), being the selected Planet or Satellite centred in the screen. In fact, in this mode the selected body is always centred in the screen, no matter how you change the point of observation.

The Teleport Navigation mode is selected by clicking in the corresponding button of the Tools Bar. This button has the following icon:



The point of observation can be modified in a very simple way, by means of simple mouse operations, as described below:

Change the point of observation keeping the distance constant:

If you hold down the left mouse button and move the mouse, your point of observation rotates around the centre of the selected Planet or Satellite, as if you were orbiting it. If you move the mouse horizontally, the axis of rotation is the vertical one, which points in the direction of the Ecliptic North Pole (perpendicular to the plane of Earth's orbit). If the mouse is moved vertically, the axis of rotation used points to the direction of Aries Constellation (or vernal point).

Change the distance of the point of observation:

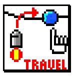
If you hold down the left mouse button while keeping the "Alt " key pressed and move the mouse, you change the distance of the point of observation to the selected Planet or Satellite. Only vertical moves of the mouse have any effect. You approach the body by moving the mouse up, and get far from it by moving the mouse down. When the Planet or Satellite is approached, its relative size in the screen gets bigger. This allows you to see the details of its surface.

Tip: *The distance to the selected body is shown in the Information Bar, located down in the main window. You will see it* *changing when moving the mouse as described above.*

The Trip Navigation mode

In this mode, when you select a Planet or Satellite, you start a space trip towards it. First, your field of view rotates until the selected body is centred in the screen. After that, the field of view approaches the body until reaching a distance of three body radius. The trip is executed in about 15 seconds.

The Trip Navigation mode is selected by clicking in the corresponding button of the Tools Bar. This button has the following icon:



The point of observation can be modified in a very simple way, by means of simple mouse operations, as described below:

Change the point of observation keeping the distance constant:

If you hold down the left mouse button and move the mouse, your point of observation rotates around the centre of the position occupied by the selected Planet or Satellite when you selected it. If you move the mouse horizontally, the axis of rotation is the vertical one, which points in the direction of the Ecliptic North Pole (perpendicular to the plane of Earth's orbit). If the mouse is moved vertically, the axis of rotation used points to the direction of Aries Constellation (or vernal point).

Change the distance of the point of observation:

If you hold down the left mouse button while keeping the "Alt " key pressed and move the mouse, you change the distance of the point of observation to the selected Planet or Satellite. Only vertical moves of the mouse have any effect. You approach the body by moving the mouse up, and get far from it by moving the mouse down. When the Planet or Satellite is approached, its relative size in the screen gets bigger. This allows you to see the details of its surface.

The Fly Navigation mode

This navigation mode allows you to explore the surface of a Planet or Satellite by making a low altitude flight over it. The flight is controlled by the mouse giving you total control of the way you want to explore.

The Fly Navigation mode is selected by clicking in the corresponding button of the Tools Bar. This button has the following icon:

Upon activation of the Fly Navigation mode, you start a flight that progressively approaches you to the selected Planet or Satellite, until you stop in a point over the surface of the body. This point is located at an altitude of approximately 10% of the body radius (i.e. 630 km for the Earth), and looking parallel to the horizon of the Planet or Satellite. From that moment on, you will be ready to start a low orbit flight, that is controlled in the following way:

Change the position and speed of the flight

If you hold down the left mouse button and move the mouse, you start to fly over the Planet or Satellite surface. Up and down movements of the mouse control the speed of advancement in the forward or backward directions. The bigger the movement of the mouse, the higher is the speed of the flight. You can decrease the speed by moving the mouse down. It is also possible to move backwards. Right and left movements of the mouse control the speed of rotation of your flight, allowing you to change the direction of your flight (that is you turn right or left). As you move, the portion of the sky that is visible changes. The effect is the same as if you were piloting the Space Shuttle in a very low orbit trip.

Change the point of observation

If you hold down the left mouse button while keeping the "Alt " key pressed and move the mouse, you change the point of the sky that you are looking at, without changing your position relative to the selected Planet or Satellite. In this way, you can freely have a look to any portion of the sky around you.

Tip: *While in Fly mode, try to look to a nearby body, centring it on the screen, and zoom-in (see Chapter 3 for details on the zoom tool). You will be able to see the centred body with high level of detail.*

The Track Navigation mode

When in Fly mode (and only in this case), the Track navigation allows you to follow automatically any planet or satellite as it moves in its interstellar course. The desired body to track will be continuously centred in the screen, being followed by your camera. It is still possible to use the Fly mode mouse controls to change the point of observation, but only in the forward/backward direction (no right or left turns are allowed, in order to keep the body to track always centred in the screen). The track navigation mode is activated by clicking in the Tools Bar button with the following icon:

Tip: *Try to track the Moon from the Earth when it starts to descend below Earth's horizon. Zoom-in to the maximum. The image obtained is really beautiful.*

Identifying and selecting objects in the sky.

You have two ways of selecting the Planet or Satellite to be centred in the screen. You can use the combo box located in the Tools Bar (see Chapter 3 for a complete description of it) or alternatively, you can click this the left mouse button over the desired body.

Chapter 3

The Tools Bar

Much of the functionality of The Planets Explorer is built into the Tools Bar, which runs across the top of the main window. The controls can be subdivided into 3 categories: those that allow you to select astronomical bodies, either to highlight them or to centre in screen, those that control the navigation mode and those that control time.

Full Screen Mode

The full screen mode button is used to make the 3D rendering window to appear as big as possible. The Planets Explorer Window is maximized, and both the Tools Bar and the Information Bar are made not visible. Like that, the 3D windows occupies the maximum area of the screen.

When in full screen mode, only the menus are accesible, but not other controls. To go back to normal screen mode, you need to press the Esc key.

Full screen mode in entered by clicking on the button with the following icon:

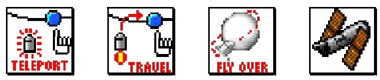
Selecting Objects in the Sky

Many of the actions that can be performed with The Planets Explorer require you to select a Planet or Satellite of the Solar System (for instance, to have it centered in the screen). This is done by selecting the desired body by means of the combo box situated in the Tools Bar, under the title "Planet Selection". Any Planet or Satellite can be selected in this way. Additionally, Planets or Satellites can be selected by clicking on them with left mouse button.

On top of selecting Planets and Satellites, The Tools Bar has another tool that allows you to highlight the shape of any of the 88 constellations in the sky. By using the "Constellation Selection" combo box, you will be able to select a constellation, which will be represented in yellow color, instead of the default grey.

Navigation Controls

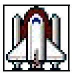
The Tools Bar gives you quick access to the selection of the navigation mode. A set of four buttons allow you to select the desired navigation mode with a single mouse click. The four buttons allowing change of navigation mode are the following:



Trip Controls

Run Trip

With this button the programmed trip is executed. The trip is visualized in the main 3D rendering screen as a movie, starting with stage number 0, and continuing with the rest step by step. There is a gap of a few seconds stop from stage to stage if the destination planet is different from the current stage one. In case the next stage corresponds to the same Planet as the current one, then this gap is zero, in order that different views of the same Planet are visualized continuously. The corresponding button icos is the following:

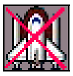


Prior to starting the trip, the Planets movement around the Sun is stopped, and every Planet is positioned in its starting position (the one occupied at Initial date). Nor mal movement is resumed when the trip ends or its interrupted by the user.

See the Trip Planner tool description for more information on this feature.

Stop Trip

A running trip can be stopped at any time by pressing the Stop Trip button. Please, make sure not to press this button if a trip is not runnning. The corresponding icon is:



Manipulating Time

The ability to control time offers you great power and potential for learning. Events in astronomy occur over a wide range of time scales. The total darkness of a solar eclipse lasts but a few brief minutes, while the appearance of the constellations changes only slightly over many thousands of years.

One of the nice things about The Planets Explorer is that you can change the rate at which time flows. Just like nature programs use time-lapse photography to show processes that take place too slow to see in real time, you can speed up or slow down time to get the best possible views of an astronomical event.

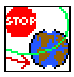
The basic tool for controlling the flow of time in The Planets Explorer is the Time Control Slider. By simply sliding the knob, you change the speed at which time flows from the fastest pace of one day in one second (slider located at the right end), to the slowest of one day in one thousand seconds (i.e. around three times faster than real time, when the slider is situated at the left end). The units reflected in the slider tool are "program time seconds" required for one "real time day of 24 hours".

Other two controls are related to time operations, and allow you to "freeze" the translational movements of Planets or Satellites in their orbits. These controls are described below:

Stop Planets

When this button is acivated, the Planets movement oround the Sun is stopped. Clicking again on this button will make the Planet to orbit again around the Sun. Please, make sure that this button is activated when editing a trip (that is, when changing the data corresponding to one stage). Otherwise, the information recorded will not correspond to the position at point zero, but that of the current moment. In this case, when running the trip, the visualized position might not correspond with the current position occupied by the Planet, thus this would not be visible.

The corresponding icon is the following:



Stop Satellites

The same function is available for the Satellites. Upon activation of this button, the movement of the Satellite around its parent Planet is stopped. Clicking again in the button will resume the orbit of the Satellite.

Chapter 4

The Menus Bar

The Menus Bar is located on top of the main application window. It is used for basic configuration operations and for the activation of the different tools provided with The Planets Explorer, as described below.

The File Menu

Currently, the File Menu has only the exit function, used to terminate The Planets Explorer. Another way to terminate the program is clicking in the close window button.

The Configuration Menu

Show Constellations

This menu is used to show/hide the lines that draw the Constellation. By default this option is not enabled.

Show Ecliptic

The menu item is used to show or hide the red line representing the ecliptic plane intersection with the stars background. The ecliptic plane is the plane where the Earth orbit is located. Most of the Planets have orbits in planes almost parallel to the ecliptic plane, thus the ecliptic line provides a usefull mean to get oriented in the Solar System and know where to look to find the Planets.

Field of View

The Planets Explorer opens with a 90° field of view. This means you are viewing a 90° slice of the 360° panorama of the sky. We call this the normal field of view, since it approximates a view of the sky that you see with your own eyes, including some peripheral vision. If you look through binoculars, the area you see is a much smaller piece of the sky, which means binoculars have a correspondingly smaller field of view. Telescopes have an even smaller field of view than binoculars.

The Field of View Menu allows you to choose between three different angles for the field of view: 90° (the default value), 60° and 45°. You just need to click in the corresponding button to select the desired value.

Another way to change your field of view is to use the Zoom feature. It is activated by keeping pressed the right mouse button and moving it in the vertical direction. If you move the mouse in the down direction, you zoom out to a larger field of view, while if you move it up, it zooms in to a smaller field of view, thereby magnifying the image you see on screen..

It is important to remember that when you zoom in on objects, you are not in fact changing your location. Think of zooming as looking through a more and more powerful telescope, while your feet remain firmly planted. Unless you've locked onto an object, The Planets Explorer displays the effects of the Planets or Satellite's rotation, so at a high magnification, stars and planets quickly rotate out of view.

Initial Date

This menu opens a windows used to select an important parameter in the functioning of The Planets Explorer: the Initial date.

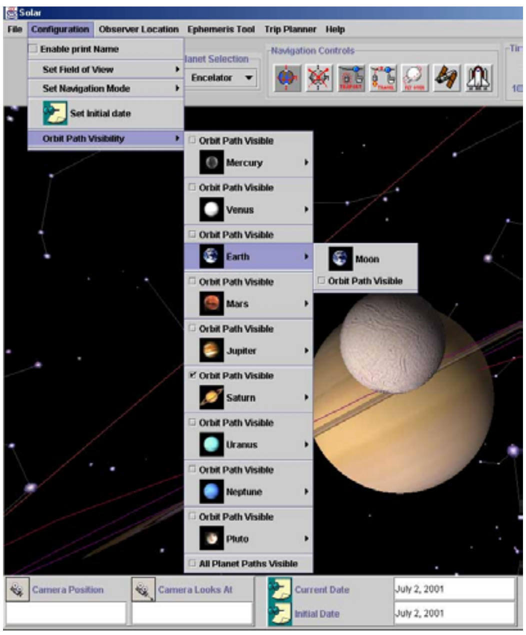
The Initial date sets the starting point in time from which all Astronomical calculations are performed. This date fixes the starting position of every body in the Solar System. Time advances from this initial date at the pace selected with the time control slider. Every time that the time control slider is used, all Astronomical calculations start again from the Initial Date, and Planets and Satellites are positioned accordingly.

Orbit Path Visibility

This menu is used to draw the orbits of the Planets or Satellites. Every Planet`s orbit can be individually selected to be drawn, by clicking in the corresponding check box. A new click on the check box will erase the drawn orbit path. It is also possible to select all Planets.

If a Planet has Satellites, the corresponding menu has a submenu, which allows to draw the orbit of its satellites, either individually or all at the same time.

The following figure shows the aspect of the Orbit Path Visibility menu.



Settings

This menu item gives access to the dialog used to define some configuration settings. Two kinds of settings are configurable: graphics/textures quality and Planets and Satellites scaling. A tabbed pane is available for this two settings configuration and saving.

You can select amongst 4 different sets of textures quality: Low quality textures (typically used when your graphics card has less than 8 Mbytes of RAM or its 3D acceleration capability is not high), Medium quality textures (for cards with 8 Mbytes RAM), Medium-High quality, recommended for cards with 16 Mbytes RAM and Very High textures quality, that must be used only in case your graphic card is a high performance one with at least 32 Mbytes RAM.

For the scale of Planets and Satellites, you can use the value of x1 (proportional to Solar System distances), x10 (10 times proportion), x100 (100 times) and x1000 (bodies 1000 times bigger in proportion to Solar System distances). A good choice for relative scale between Planets and Satellites is to use Stallites scaling 10 times bigger than the one selected for The Planets. This is a good trade-off between realism (obtained when both scaling factors are equal) and nice views (the Satellites are usualli very small, and its relative size when seen from their Planets is small).

A special case has been defined for the Moon and the Sun. The Moon is an untypically big Satellite (more than 1700 km radius). If the scale factor choosen is 10 times bigger than that of the Planets, it would mean that it is represented with a bigger size than the Earth. To solve this problem and still keep a reasonable view, the scale of the Moon is always 3 times bigger than Planets scales when Satellites scales are bigger than Planets ones, and equal to Planets scale if both scales selected are the same.

The size of the Sun is modified in order that its relative size as seen from the Earth is equal to the apparent size of the

Moon when also seen from the Earth (this is the real case). Like that, no matter the scaling factor selected, the Sus and the Moon are seen with the same size from the Earth, thus it is possible to visualize solar eclipses.

The selected settings must be saved before exiting the settings dialog, in order that next time The Planets Explorer is opened they will be the new default values. Please, reemember that the selected settings will only apply next time that The Planets Explorer is run.

The Observer Location Menu

The Observer Location Menu allows you to open the window used to select the location on Earth from which you are going to make Astronomical calculation on Ephemeris. It is not used to select the point of view from which you are observing the sky. For that purpose, the different navigation controls give you total selection freedom.

Changing Your Viewing Location

For every different location on Earth, the night sky reveals a unique face. Australians never lay eyes on the North Star, while stargazers in the northern latitudes find the nearby galaxies known as the Magellanic Clouds forever hidden from view. Our place on Earth determines when the sun rises and sets, where and when the planets sweep across the sky, and what constellations we can see. Or at least it used to. With The Planets Explorer, you can travel around the Earth or any body of the solar system.

The Observer Location window allows you to select a new city from the locations or enter a new latitude and longitude. Press OK when you are done. If you don't know the exact co-ordinates, but just want to calculate from an approximate location somewhere on earth, click anywhere on the world map. A small red circle appears at your new choice. Press OK and you will be set at your new location.

Given that The Planets Explorer gives the user total freedom to select the point of view, including any point on the Earth´s surface when in Fly navigation mode, the coordinates selected through the Observer Location menu are only used to set the observation point in the Ephemeris Tool calculations, that is, to define the Elevation and Azimuth coordinates. See Chapter 6 for a description of the different coordinates systems used in Astronomy.

The Ephemeris Tool Menu

The ephemeris tool is used to calculate the coordinates of Solar System bodies in the desired date and from the selected location on Earth for observation. The coordinates are presented in a table, giving the numerical values for the different angles and distances of every Planet and Satellite of the Solar System. See Chapter 6 for more information and definition of the different coordinates systems used in Astronomy.

The Ephemeris tool can be accessed by selecting the "Open Ephemeris Tool" item in the Ephemeris menu.

The Ephemeris Tool window is divided in three sections. The top section includes the controls used to select the date and time for the calculation of the desired ephemeris. Once the corresponding date and time have been selected, the "Calculate" button must be pressed for the Ephemeris Tool to update the values in the table. The "cancel" button closes the window.

The central section presents the numerical values for the different coordinates in a table form. For every Planet and Satellite, the following values are given: RA (Right Ascension), Declination, Azimuth, Elevation, hLong (heliocentric longitude), hLat. (heliocentric latitude) and distance. The distances are presented in km or million km, and represent the distance to the Sun (in the case of the Planets) or the distance to their corresponding Planet (in the case of Satellites). The other coordinates, being angular values, are expressed in degrees, minutes and seconds, with the exception of the Right Ascension values, which is expressed in hours, minutes and seconds for historical reasons.

The lower section presents the name of the city of observation for the calculation of the coordinates, presenting also the longitude and latitude of such observation point. Additionally, the "Select" button gives direst access to the Observer Location window, described before. If the observation point is changed, upon return to the Ephemeris Tool window the "Calculate" button must be pressed, in order to update the values in the coordinates table to reflect the change in observation point. Please, note that only the Azimuth and Elevation values depend on the point or city of observation. All the other coordinates depend exclusively on the date and time of calculation.

Note: *All calculations performed by the Ephemeris Tool are referred to the reference system defined for J2000 date. Co-ordinates presented might not correspond with data presented in publicly available tables, which are usually referred to the reference system of the date. The difference between both data is the correction due to precession and nutation.*

However, the change of orientation of Planets and Satellites rotation axis is calculated by The Planets Explorer, and used for the 3D representation, although the reference used for ephemeris is always J2000.

The Trip Planner Menu

The Trip Planner is a tool used to create files that define trips through the Solar System. These trips can be visualized at any moment. Each trip is composed by a number of stages, defined by the Planet the user is visiting during such stage. The view of the Planet can be defined at will, using the mouse controls of the 3D rendering screen. The Planets Explorer will interpolate a trajectory between the programmed stages, resulting in a "movie" that can be seen every time the trip is executed. It is possible that consecutive stages are centered in the same Planet. In this case, The Planets Explorer will interpolate orbital movements that change the view of the Planet without travelling to a different bodie.

The Trip Planner can be considered as an editor. The different stages of the trip are presented in a table form, which presents the stage number, the name of the Planet being visited and the distance to such Planet when the user arrives to the end of the corresponding stage. In combination with the controls of The Planets Explorer main screen, the user changes the view of the Planet in the selected stage, or changes the Planet. The following paragraphs describe how to use the Trip Planner tool.

Menus

Two menus are available in the Trip Planner. The **File** menu is used to select, open and save the file corresponding to the trip being edited. Three possibilities can be selected: **Open**, used to load an existing Trip Planner File, **Save**, used to store the current data, as presenetd in the table, in the selected file, and **Save as**, which allows the user to select a name for the file being edited and saved. The final option, **Exit**, closes the Trip Planner.

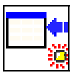
The **Help** menu allows the user to gather information on the release of the Trip Planner being used, through the use of the **About** item.

Tools Bar

The tools bar presents five buttons providing the following functionality:

Insert Key

This function inserts a new trip stage immediately after the currently selected stage. By default, the inserted key has the same data than the previously selected one. When in editing mode, the new stage can be edited in the same way as previous ones, using the controls of The planets Explorer main window. The button used to activate the Insert Key function has the following icon:



Edit Mode

This function is used to activate the edition mode. The data corresponding to every stage can only be modified when in edit mode. The function is de-activated by clicking again in the same button. When in editing mode, the lower part of the Trip Planner window dispalys a message indicating "Editing file …" and the name of the file. When edit mode is de-activated, the messages indicates "Active file…" and the name of the file currently selected.

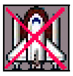
When in edit mode, the selected stage, that appears in blue color in the stages table, can be modified, using the controls of The Planets Explorer main window. The Planet being visited in this stage can be selected through the planet selecction combo of the tools bar. The view of the planet can be manipulated through the standard mouse controls of the 3D rendering window. Both point of view and distance to the selected planet can be changed with the mouse. When the mouse button is released, the corresponding data is stored in the information of the selected stage. This is the information that will be used when the trip is executed. Edit mode is activated with the button with the following icon:

Run Trip

With this button the programmed trip is executed. The trip is visualized in the main 3D rendering screen as a movie, starting with stage number 0, and continuing with the rest step by step. There is a gap of a few seconds stop fro stage to stage if the destination planet is different from the current stage one. In case the next stage correspondos to the same Planet as the current one, then this gap is zero, in order that different views of the same Planet are visualized continuously. The corresponding button icos is the following:

Stop Trip

A running trip can be stopped at any time by pressing the Stop Trip button. Please, make sure not to press this button if a trip is not runnning. The corresponding icon is:



Stop Planets

This button has the same effect as the equal one of the main tools bar. The Planets movement oround the Sun is stopped. Clicking again on this button will make the Planet to orbit again around the Sun. Please, make sure that this button is activated when editing a trip (that is, when changing the data corresponding to one stage). Otherwise, the information recorded will not correspond to the position at point zero, but that of the current moment. In this case, when running the trip, the visualized position might not correspond with the current position occupied by the Planet, thus this would not be visible.

The corresponding icon is the following:

Stop Satellites

The same function is available for the Satellites. Upon activation of this button, the movement of the Satellite around its parent Planet is stopped. Clicking again in the button will resume the orbit of the Satellite.

The trip stages table

The different stages of the trip being edited or visualized are presented in a table form. For every stage, three values are presented: the stage number (from 0 to a maximum of 28), the name of the Planet being visited in the stage and the final distance to the Planet to be reached in this stage.

The selected stage, that is, the one whose data will be modified in edit mode, is marked with a blue background.

Chapter 5

The Information Bar

The Information Bar, located in the lower part of The Planets Explorer Window, provides real time information on the Solar System scene that you are watching in the main 3D rendering view.

The information provided is the following:

Current Date

This field tells you what is the current date being computed. What you see in the 3D rendering area represents the status (position in the orbit, rotation angle and rotation axis orientation) of Solar System bodies at such date. As explained in previous chapters, The Planets Explorer allows you to manipulate time flow speed, by using the time manipulation controls. If for instance you decide to accelerate the flow of time, you will see that the information presented in the current Date field is updated accordingly (that is, you will see the date increasing often, up to the maximum pace of 1 day per second). The starting point in time for all astronomical calculations performed by The Planets Explorer is fixed by the Initial Date field.

Please, note that current date information is not updated if the translation of planets or Satellites is stoped.

Initial Date

This field informs of the date that is used as starting time for astronomical computations. The user, through the Configuration menu, can select the initial date. Every time that time manipulation controls are activated, the astronomical computations resume from the starting date, and the Current Date field is updated accordingly. This gives you the possibility to "see" the Solar System as it looks at the date of your choice, and see how it evolves as the days flow. Additionally you have the power to "freeze" the Solar System at any date, by means of a combination of time control actions and Set initial date in Configuration menu.

Selected Body

This field informs you of the Solar System body that has been selected. In most navigation modes, the selection also means that the corresponding body will always be centred in the screen (that is, "you" are locked to the body, and continuously follow it in its course through space). If you have decided to rotate with the body, you will immediately realise that you can no longer see the body rotating, but you see the background stars moving instead. Do not worry, this is exactly what you would see if you were orbiting the body in a synchronous orbit.

Distance to body

This field tells you what is the apparent distance to the selected Solar System body. By "apparent" we mean that what you see in the screen is how the corresponding Planet or Satellite would look like if you were at such distance. Remember that you can change this distance by simple mouse actions, as explained in Chapter 4 . As you do it, you will see that the Distance to body field information is updated accordingly.

Chapter 6

The Planets Explorer as Learning Tool

In previous chapters, you have learned the features of The Planets Explorer and how to use them. It is now time to examine how you can exploit such features to enjoy the wonders of the Solar System and to learn a little bit how the movements of Planets and Satellites work.

The following paragraphs will give you some practical examples of the things you can do and the lessons you can learn by using The Planets Explorer. These are just examples. The possibilities of The Planets Explorer are huge. Do not hesitate to explore the Solar System in any way you can imagine. Try the different options. Look for beautiful images or nice points of view. Almost anything you can imagine is possible with The Planets Explorer. Thus, activate your imagination and get ready for a fantastic tour of our Solar System.

A basic thing: Earth´s rotation and the apparent movement of stars

When you look at the night sky, you realise that if you compare the view at the beginning of the evening to the one at midnight, you see that the stars have shifted their position. The movement of the stars is the most obvious effect of the passage of time, but the reality is that stars are basically fixed with respect to the Sun and Planets. This shift in position is the effect of the Earth rotating on its axis. Seen from the Earth, the stars (and also the Sun, Moon and every celestial body) describe circular paths centred in a point of the sky located nearby Polaris, the North Star. This is so because Earth rotation axis is oriented in the direction that points to such star, thus rotation has no apparent effect on it.

With The Planets Explorer you can visualise this phenomenon. Select the Earth as the observation body and activate the "do not lock to rotation" mode of view by clicking in the corresponding button of the Tools Bar. The Earth will appear in the centre of the screen and rotating. You can use the time manipulation controls to visualise different rotation speeds. You will see that the stars are fixed. You can get closer to the Earth, or further away, but the stars will continue to be fixed. This is the effect of stars being so far away that, from the point of view of one observer always within the Solar System, the distances travelled are very small.

Change now to the "lock to rotation" mode of view. You will immediately notice that the Earth rotation stops (it is not that rotation stopped, but you are now rotating with the Earth, thus from your point of view the Earth has stopped rotating). This is exactly what you feel when in the surface of the Earth. Now you see the stars are shifting position (do not get confused, in reality is you who are shifting position). If you look carefully, you will see that the shift in position is circular. Lets now see where is the centre of this circular path.

Using the constellations selection combo from the Tools Bar, select "Ursa Minor" constellation. Upon selection, it will be highlighted in yellow colour. The star located at the extreme of "Ursa Minor" is Polaris, the northern star. The Earth rotation axis points in the direction of Polaris, thus as the Earth rotates, the apparent position of this star does not shift. Moreover, all the stars move in circular paths around Polaris, which is located right in the centre of the different circles drawn by every star.

Now locate "Ursa Minor" in the screen, by dragging with the mouse to change your observation point, until it is visible in the 3D screen. In order to easily locate this constellation, you can drag until what you see from the Earth is the south polar cap. This sets your observation point in the line that joins the south pole and Earth´s centre, that is, the line of Earth rotation axis.

Once "Ursa Minor" is located, you can see that all the stars describe circular path around Polaris, the extreme of "Ursa Minor". Play with the time control tool if you want time to flow faster. This will make the apparent movement of stars to occur faster.

The phenomenon described above is what you experience when watching at the night sky. In fact, it has been used for centuries by people to get oriented during the night. No matter where you are, Polaris is always there, easy to find, pointing to the north precisely like a compass.

A beautiful moon: Phobos, Mars's smaller satellite.

Mars has two satellites: Phobos and Deimos. They are very small, about 7 and 13 km wide respectively, and describe orbits very close to the Planet and thus very quickly. Phobos completely orbits around Mars three times in one day.

Along the billions of years since the Solar System exists, Phobos has suffered the impact of countless bodies, until its shape has been modified to look like a "potato". Let's have a look at it.

Select Phobos with the combo in the Tools Bar. The first thing you will realise when it appears on the screen is that it rotates fast. This is due to its small size, that makes it rotate very close to Mars. Like the majority of satellites, the rotation around its axis is synchronised with the translation period around its central body (Mars). This phenomenon is called the "tidal effect".

You can see now the general shape of Phobos, which is not spherical. You can also see a big crater, result of a huge collision billions of years ago. This crater is called Stickney.

If you want to get a beautiful view of Phobos in a background almost completely filled by Mars, please follow the following steps: with the ALT key pressed, drag with the mouse in down direction. As explained in chapter 3. This has the effect of moving your point of view away from the selected body. When you see Phobos small, make use of the zoom tool to "zoom in" (by dragging with the mouse right button pressed). You will see that again the size of Phobos in the screen gets bigger, but also all the rest of the background is now bigger, as if you were using a powerful telescope. If you wait a little bit, you will see Mars moving fast on the screen, as if moving around Phobos. In fact is Phobos which orbits around Mars but, as your point of view is "locked" to Phobos, you see Mars moving instead. Make use of the time control tool if you want to freeze Mars as background of the centred Phobos. The result is a beautiful image of the Mars/Phobos system.

The synchronous orbits of most satellites

The orbits of most satellites are synchronous, i.e. the rotation period around its axis is identical to the translation period to complete one orbit around its parent planet. There is a reason for that, known as the "tidal effect": tidal forces acting over the molten nucleus of satellites for aeons since the birth of the Solar System have progressively slowed down its rotation. But, as soon as such rotation period equals that of the translation, tidal forces stop acting thus the rotation and translation periods remain identical.

Tidal forces act on all Solar System bodies, including the Earth. The rotation period of Earth is very slowly decreasing, thus the duration of the day is longer. But this effect is very weak, and it will take billions of years to reduce it to the same value of translation (365 days). The closer to the Sun, the strongest are tidal forces. That is why Mercury rotation period is so slow. In the case of the satellites, as their masses are small, tidal forces act quickly, and, at the present moment of Solar System life, they have had time enough to synchronise the orbits.

The visible effect of such synchronism is that, seen from the planet, every satellite always presents the same face. Half of the satellite surface is permanently hidden to the parent planet.

With The Planets Explorer you can see this fact in action. Let us first have a look to the Moon from Earth. Select the Earth and change to Track navigation mode. The Moon will appear centred in the screen, and will be continuously followed. You will see that, no matter how fast time goes on (you can use the time manipulation controls to make time flow at its maximum speed), what you see from the Moon is always the same surface. Half of the Moon is hidden for observation from Earth's surface. Remeber that you are locked to the Earth in this navigation mode. However, if you select the Moon and change to Teleport navigation mode, you can see the Moon rotating, and can observe every part of the Moon's surface. This is so because your observation point is no longer locked to the Earth, and you are free to orbit the Moon from any distance and position.

In fact, its was not until the NASA´s Apollo mission orbited the Moon in the sixties that the "hidden face of the Moon" could be seen and photographed for the first time.

There is another way of visualising that orbits of most satellites are synchronous. Let's take now one of Jupiter satellites, Io, as example. When in Teleport navigation mode, select Io as the body to follow. Io will be centred in the 3D screen and, if you are not locked to the rotation, you will get an image of Io rotating. From time to time, you will see Jupiter passing by, as if rotating around Io. In fact is Io the body that orbits around Jupiter, but, as you have chosen to lock to Io, from your point of view is Jupiter the body that moves. Do not miss the beauty of Io, with its reach and colourful surface, due to the volcanoes that are permanently active and changing Io´s surface.

Now change to the lock to rotation mode. The image of Io will stop rotating, and you will see the rest of the bodies rotating instead. By using the mouse controls, locate Jupiter in the sky. You will immediately notice that now Jupiter is fixed in the sky. The stars and other Solar System bodies continue moving, but Jupiter is fixed. This is due to the synchronism of the orbits: in the same way that seen from Jupiter, Io presents always the same face, seen from the surface of Io Jupiter position is fixed in the sky. You can see the rotation of Jupiter, but its position does not change. If you landed in Io, in a place of the face heading to Jupiter, you would always have the beauty of Jupiter present in your sky, no matter it is day or night. You could witness dawn and sun setting in Jupiter, and in your own place in Io, and still Jupiter would be fixed in the sky.

Saturn rings

It is a known fact that many gas giant planets have planetary ring systems. Out of these, undoubtedly Saturn has the most beautiful planetary ring system of the Solar System. With The Planets Explorer you can have a look to it. A very nice observation point for Saturn's planetary ring is its closest moon: Mimas. It is a small satellite, orbiting Saturn just out of the outer rings, and thus very close to them. Orbiting period is fast.

You can change to Teleport navigation mode and select Mimas. You will very soon observe that being so close to the planet, Saturn occupies a big portion of the visible sky from Mimas, thus you have a wonderful platform of observation of both Saturn and its planetary ring system. Do not hesitate to play with the mouse controls to explore different points of view. You can also choose another satellite as observation point. For instance, Tethys will give you the opportunity to have nice views of Saturn and, from time to time, you will even see Mimas orbiting Saturn right at the edge of the rings. In order to help you localise Mimas in this case, you can make use of the orbit path visualisation tool.

If you change to "lock to rotation" mode, you will see another interesting phenomenon. When you are locked to rotation, your local coordinates system is oriented with the rotation axis. The rotation axis of most satellites is perpendicular to the plane of its orbit around the main planet. Additionally, the plane of the orbit is almost parallel to the equator of the planet. This means that your point of view is always perpendicular to the equator, that is, perpendicular to the plane of the ring system. That is why you can barely see the rings in this mode. Only the small inclination of the orbit of Saturn satellites makes it possible to see the rings from the surface of such satellites.

The fact that satellites tend to orbit their planets in orbits parallel to the planet's equator is relatively common. This is the case for the satellites of gas giants for which, given the relatively long distance to the Sun and the big mass of these planets, the predominant gravitational forces are those created by the planet itself. In these circumstances, the most stable situation is that of satellite orbits almost parallel to the equator.

This is not the case for the Moon, Earth´s satellite. As the Earth is relatively close to the Sun, and being the mass of the Earth not as big as for the gas giants, the predominant gravitational forces acting on the Moon are those of the Earth but also the Sun. The orbit of the Moon is not parallel to Earth´s equator. In fact, it is only slightly inclined versus the plane of Earth´s orbit around the Sun, that is, the ecliptic plane, instead of being almost parallel to the equator (which is inclined about 23 degrees with respect to the ecliptic).

A Solar eclipse

Solar eclipses occur when the Sun, the Moon and the Earth get located in the same line, being the Moon located between the Sun and the Earth. In such occasions, the Sun is occulted and a shadow projected on the Earth's surface. The areas where the Sun is completely obscured by the Moon experience a total eclipse; the areas where such occultation is not total experience a partial eclipse.

The plane of Moon's orbit around the Earth is slightly inclined with respect to the plane of Earth's orbit around the Sun. Due to that, solar eclipses do not happen every month (one month is approximately the time the Moon needs to complete its orbit around the Earth).

Instead, Solar eclipses only occur when the Moon is located in the point of its orbit where the planes of both orbits intercept each other (this is the only point where the three bodies can be in the same straight line. In other positions of their orbits the three bodies are in different planes, thus can not be aligned).

With The Planet Explorer, you can watch the whole process of a solar eclipse. To do that, when in fly navigation mode select the Earth as the centred body in the screen. You will jump to a point of view located at a low altitude position over the surface, looking at the horizon. Now configure the initial date to a few days before August 11th, 1999. This was the date of the last total solar eclipse seen from Europe. Once the scene appears on the 3D-rendering screen, make use of the tracking navigation mode to "track" the movement of the Moon from just above the surface of the Earth. You can use the mouse navigation controls to change your position over the surface of the Earth, in case the Moon is under the horizon in your current position over the Earth.

You are now ready to watch the eclipse happen. Check what is the current date in the information bar. In case time is flowing too fast or too slow, remember that you can change it at any time with the time manipulation controls. Please, make sure that current date is just before August 11th. If necessary, you can change the initial date to make sure that you will be able to watch the moments preceding the eclipse. Now follow the movement of the Moon (or more precisely, as the Moon is being "tracked", the movements of other celestial bodies). You will see that the position of the Moon and that of the Sun are approaching, until, at a moment during August 11th, both positions coincide, and the Moon is obscuring the Sun. You should be able to see that the Sun is completely obscured by the Moon (or almost completely, depending of the exact position above Earth's surface you are located, as total solar eclipses can only be seen in a very narrow area of the Earth).

You have witnessed the total solar eclipse that happened on August 11th, 1999. You can try other dates (for instance, there will be another total solar eclipse visible from the north pole area in August 2008). You can also verify the duration of the eclipse, which should be a few minutes of "real" time.

Chapter 7

Astronomical Data

Astronomical Calculations

Knowing with high precision the position of main bodies of the Solar System is an extremely complex issue. Even though the law governing movement (gravity) is very well known, and the parameters required to calculate positions and speeds are also known (masses, velocities and distances at a given moment for the different planets and satellites), the fact is that Newton equation for the gravity when more than three bodies are involved has no analytical solution.

There are different approaches to predict the position of Solar System bodies at given dates and times. The highest precision is obtained by numerical integration of the positions and speeds known at a given moment, making use of very powerful computers. This gives the best results of precision over very long periods of time, but it takes a lot of time and computing power to get good results, thus it is not useful when almost real time is required. There are analytical theories that allow to get formulas used to calculate the position of planets and satellites with relatively high precision for given periods of time. These theories are usually based on numerical series of coefficients that take into account the gravitational effect of nearby big objects and neglect the effect of distant or small bodies. These effects are usually described as periodic "perturbations" to the simplest of the orbits, as results of the application of Newton gravity law to the problem of two bodies (this has been solved analytically, resulting in the equation of an ellipse with the central body located in one of the focus). This is based on observations carried out during several centuries now, showing that Solar System bodies describe orbits very close to ellipses. The coefficients predicted by the theories are then matched to observations. The results obtained give good precision over relatively long periods of time (several thousand years).

The Planets Explorer uses a combination of different theories to calculate the position of planets and satellites. A low precision algorithm is used to calculate the position of the planets and to render their images in the 3D screen. This algorithm assumes elliptical orbits governed by Kepler´s law, and uses elliptical orbital elements (there are 6 orbital elements required to fully define the position and orientation of an elliptical orbit in space) to calculate the position of a planet. As the orbital elements have been calculated to match exactly the known positions of the planets in year 2000, the closer to that date the higher is the precision of the calculations. Precision is reasonably good for a few centuries before and after year 2000, enough for an accurate representation in the screen but not enough for ephemeris calculations.

The Ephemeris Tool uses a higher precision algorithm to perform precise ephemeris calculation. The theory used is the VSOP 87 series, developed by P. Bretagnon and G. Francou, which gives good precision for a time span that goes from 2000 BC to 3000 AD.

The analytical calculation of the orbits of the satellites is relatively more complex, due to the fact that some of the satellites are very small, and data concerning their positions is not as well known as for the big planets. The Planets Explorer uses different theories for the different satellite systems of every planet. For Mars, the theory used was developed by A.T. Sinclair and published by the Astronomy & Astrophysics Journal in 1989 ("The orbits of the satellites of Mars determined from Earth-based and spacecraft observations").

For Jupiter, the formulae have been taken from Jean Meeus Astronomical Algorithms.

Saturn satellites position calculation is based on G. Dourneau theory ("Orbital elements of the eight major satellites of Saturn determined from a fit of their theories of motion to observation from 1886 to 1985", Astronomy & Astrophysics 1993).

For Uranus satellites, the theory used for the calculation was developed by J. Laskar and R.A. Jacobson (GUST86, An analytical ephemeris of the Uranian satellites, Astronomy & Astrophysics 1987)

The origin for most of these theories was the need to predict the position of the satellites prior to the arrival of Voyager mission to the different planetary systems during the eighties. The need to precisely guide the ship and point its cameras to get the first close range pictures of many satellites was at the origin of such developments, which proved extremely successful. In fact, many of the pictures used to create the textures files used by The Planets Explorer are the direct result of the work of people from the Jet Propulsion Laboratory and NASA in the development of the theories and technologies that made possible the success of the Voyager and other NASA missions.

Textures

Textures are the image files used by The Planets Explorer to render realistic images of the Planets and Satellites. These textures have been composed by a mosaic of photographs that have been taken mostly by the different NASA probes that have explored the Solar System during the last years. The different Mars missions (Mariner, Viking I & II, Mars Global Surveyor) and the extremely successful Voyager mission took most of the pictures.

The result is that the images rendered by The Planets Explorer are very realistic, equivalent to pictures taken from a very short range and of a much higher quality that equivalent pictures taken by the most powerful telescopes.

However, the available information has not the same accuracy for the different Solar System bodies. The mosaics for The Earth, the Moon, Mars and the four galillean moons are very accurate, resulting in high definition images for those bodies. On the other hand, the images available for some of Saturn and Uranus moons is either incomplete or not existing, as the Voyager mission was not able to take whole pictures of every of them. For those bodies, the textures have been artistically reconstructed, trying in any case to create images as close as possible to the reality.

Highly realistic images require big texture files, thus very high memory occupation. A trade off between memory availability, processing speed and quality of the graphics is always necessary. The Planets Explorer uses very high definition textures for the Earth, the Moon, Mars and the 4 galillean moons, and lower definition for the remaining bodies. Do not miss the images rendered of these bodies when looking from a short range.

Co-ordinate Systems:

Looking up into the night sky, you can imagine that the stars are fixed to an imaginary sphere surrounding our planet. To specify locations on this celestial sphere, astronomers use a system of co-ordinates similar to the latitude and longitude measurements used to map Earth.

The Ephemeris Tool can display the values for the co-ordinates of objects in several co-ordinate systems. All spherical co-ordinate systems require two independent co-ordinates, which are determined by an object's distance from two "great circles" which are perpendicular to each other. For example, the great circles in Earth's latitude/ longitude co-ordinate system are the Equator and the Prime Meridian.

Local:

The two co-ordinates in this system are the altitude and the azimuth. The altitude measures how high above the horizon an object is, and is usually measured in degrees. An altitude of 0 degrees means the object is right on the horizon, and an altitude of 90 degrees means the object is directly overhead.

Azimuth measures the compass direction of an object. An object which is due north in the sky has an azimuth of 0 degrees, one that is due east has an azimuth of 90 degrees, and one that is due south has an azimuth of 180 degrees.

Equatorial:

The equatorial system is the most common system for describing the position of celestial objects. Its two co-ordinates are declination and right ascension.

Declination is the astronomical equivalent of latitude. It measures an object's angular distance north or south of the celestial equator, which is simply a projection of the Earth's equator into space (an object of 0° declination is directly on the celestial equator). Because of this, objects with positive declination can be seen more easily in the Northern Hemisphere, and objects with negative declination can be seen more easily from the Southern Hemisphere. Declination is usually measured in degrees, minutes, and seconds (°, ', "). Polaris, the North Star, has a declination of almost 90 degrees.

The east-west measurement is called the right ascension (RA), and is most often measured in hours, minutes, and seconds (h, m, s), from 0 to 24 hours. Because the earth rotates, it is not possible to equate longitude on earth with right ascension.

Think of lines of right ascension as longitude lines which are fixed in space, not rotating with the Earth like lines of longitude. The zero-point of right ascension (RA) is defined to be the right ascension of the sun at the Vernal Equinox, which is the first day of spring in the Northern Hemisphere.

The Earth is precessing on its axis of rotation (picture a spinning top which does not point straight up but instead moves in an arc around the vertical) with a period of 26000 years. Because of this, the Vernal Equinox slowly changes over time and so do the equatorial co-ordinates of an object.

These changes are quite small and often unimportant for the amateur astronomer. To standardise astronomical positions, astronomers often refer to an object's position using the co-ordinate system of a particular date. For example you will often see positions given in J2000 co-ordinates, using the equatorial co-ordinate system of Jan 1, 2000. The info window lets you display equatorial co-ordinates for the current time or the year 2000.

Ecliptic:

This reference system uses ecliptic latitude and longitude. Ecliptic latitude is similar to declination, except the plane of 0 degrees latitude is the ecliptic plane (the plane of the earth's revolution around the sun), instead of the plane of the earth's equator. The plane of ecliptic longitude also has the vernal equinox as its zero point.

Appendix A

Frequently Asked Questions

Check for the FAQ section of The Planets Explorer home page for an updated list of typical questions, tips on the use of The Planets Explorer and trip planner files provided by users of the program.

Appendix B

Acknowledgements

All the texture maps used by The Planets Explorer are ultimately based on JPL/NASA data in the public domain. They have been constructed from pictures taken by the different missions that have been exploring, and continue to do so, the Solar System. The NASA missions Voyager, Galileo, Viking and the new missions to Mars have provided the information used to consruct these textures.

Texture maps for Saturn, Venus and the foir galilean satellites were created by Bjorn Jonsson, from data obtained by Voyager and Galileo missions and made available by the USGS.

Maps for Mars, the Moon and several other bodies have been obtained from David Seal´s page (JPL/NASA).

Data for the texture of Saturn satellites has been obtained from the USGS page on the subject. Some colors have been modified, and an artistic recreation for the missing information has been used.

Textures for Uranus and Neptune, as well as data for the Earth maps has been created by James Hastings-Trew. Additional data for the Earth texture maps has been obtained from the Blue Marble project of the USGS.

Thanks to all those mentioned above for making this data available.