

**THE EARTH CENTERED UNIVERSE™**  
***Sky Visualization Software for Microsoft Windows™ 3.x***

**User's Manual**

*Version 1.4 (Manual Revision 1.4)*  
Released in April 1993

**A Product of**

*David J. Lane  
4-26 Randall Avenue  
Halifax, Nova Scotia  
Canada B3M 1E2  
Phone: (902) 443-5989  
Compuserve E-Mail: 71601,247  
Internet E-Mail: [dlane@husky1.stmarys.ca](mailto:dlane@husky1.stmarys.ca)*

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## 1. Getting Started

Thank you for choosing to purchase "The Earth Centered Universe", ECU for short. ECU is a Sky Visualization Program capable of simulating many of the phenomenon of the Earth centered sky. This includes, but is not limited to, the stars, planets, sun, and moon, comets, and "deep sky" objects. ECU is designed as an observing tool for the observing amateur astronomer, but is equally useful to the "armchair" astronomer or other person interested in astronomy.

Many of the concepts and terms used in this manual are common in amateur astronomy, but may not be familiar to all users. The author recommends the purchase of a good beginner book in astronomy as a guide to the understanding of the concepts provided by this program. An excellent beginner's book is: **NIGHTWATCH: An Equinox Guide to Viewing the Universe** by Terence Dickinson, which is available in most well stocked bookstores or libraries.

ECU is designed to operate on a PC from within the Microsoft Windows 3.0 or 3.1 environment. This environment provides all of the "tools" necessary to support a highly graphical program like ECU. This manual assumes that the user is familiar with the operation of typical Windows 3 programs.

ECU was written, because of the obvious lack of good, reasonably priced astronomy programs. Most "commercial" software products (and the author has purchased three of the high profile programs) suffer from very awkward (not intuitive at all) user interfaces and **ssllloooowwww** operation (especially without a math processor). ECU, therefore, attempts to fill an obvious need at the reasonable prices of shareware.

### 1.1 Registration of ECU

A large amount of effort in software development has gone into "The Earth Centered Universe". It currently is comprised of about 350 pages of program listing. This release, V1.4, includes a many enhancements over previous versions (ECU was first released as V1.1 in March of 1992).

The enhancements made to obtain V1.4 of ECU from V1.3 are listed below:

1. The previous zoom out limit of 60 degrees is increased to 180 degrees allowing an entire hemisphere to be seen at one time.
2. The IAU constellation boundary lines have been added.
3. When ECU starts up, it now utilizes the entire screen.
4. High quality star charts can now be printed directly to your Windows-compatible printer or plotter.
5. You can now set the colours of all sky drawing elements to suit your own tastes. You can also quickly set the sky display to "black on white" or "white on black" to allow the screen to copied and printed from other Windows applications.
6. An red only mode is provided to preserve your night vision if ECU is used in the field.
7. Labels for the right ascension and declination grid have been added.
8. The screen can now be updated in two ways; either all at once (as in V1.3) from a pre-calculated bitmap or element by element (as in V1.1).
9. You can now horizontally reverse or vertically flip (or both) the sky display to produce views which match your telescope's optical configuration. This feature can also make the sky look more realistic for those "down under".
10. There are now quick access keys to position the sky display to the North, South, East, and West points on the horizon and the Zenith.
11. There are now quick access keys to center on the Moon and Sun.
12. You can now save a configuration file such that a specified point above the local horizon (azimuth and altitude) will be recalled, rather than a specified right ascension and declination.
13. From the Identify Object dialog box, you can now precess the normally J2000.0 coordinates to the current date.
14. The star symbols have been changed to appear more realistic and make it easier to discriminate between stars of differing magnitudes.
15. You can now display GIF images of objects which have been selected.
16. When ECU is performing calculations of positions for solar system objects, a "Saturn" cursor is shown.
17. The animation trail has been changed from a dot to a small cross.
18. The animation time step can now be any arbitrary number of minutes, hours, days, or years.
19. When exiting ECU, you are now prompted to save your current configuration to the current file.
20. You can now set the time to the system clock, but not automatically update the display every minute.

21. Many other smaller items, too numerous to list.
22. Several bug fixes.

If you are using the SHAREWARE VERSION of ECU, I ask that you register it, in order to ensure that ECU is supported and greatly improved in the future. Registration will bring a printed manual and an enhanced version of ECU. This enhanced version includes several databases, which are too large to distribute by normal shareware methods (e.g.: bulletin board systems). Also, several computational enhancements (which require two of the database files) are enabled in the REGISTERED VERSION.

I ensure you that the SHAREWARE VERSION is **not** "crippled" software. It only lacks some of the advanced features, such as catalogue identification of stars, descriptions of "deep sky" objects, ultra-high accuracy solar system calculations (lower accuracy versions are included), comets, etc. The executable file is the same.

A form that can be used to register ECU is found in the file REGISTER.WRI. It can be viewed and printed by using the *Windows Write* program. It is also included at the end of this manual.

The author would be most pleased in hearing your comments and suggestions for improvements of ECU or this manual. I would also like to hear about any "bugs" which you detect so they can be fixed in a future release. ECU is a SHAREWARE product, thus is user supported. I can be reached at any of the addresses (post office and e-mail) listed on the cover page of this manual.

## 1.2 System Requirements

As stated in section 1., ECU operates within the Microsoft Windows 3 environment. It will not run under DOS alone. However, it has been tested for operation under IBM OS/2 2.0. The minimum system requirements are listed below:

Hardware:	286/386SX/386DX/486 100% PC Compatible Computer (386DX recommended)
Math Co-processor:	80x87 supported and recommended, but not required
Software:	DOS 3.x or higher Microsoft Windows 3.0 or 3.1 (standard or enhanced mode)
Memory:	Minimum 600K bytes free from within Windows Minimum 1M bytes free with enhanced stellar database (some program features, especially if you have a high resolution display, may require more memory)
Disk Capacity:	SHAREWARE VERSION - 700K bytes REGISTERED VERSION - 2.3M bytes WITH ENHANCED STELLAR DATABASE - 5.5M bytes
Graphics Card:	An EGA or better graphics card (VGA or Super VGA recommended)
Monitor:	Colour monitor recommended
Mouse:	Windows compatible
Printer (optional):	Windows compatible printer or plotter

The use of a math co-processor is supported and recommended, but not required. With most commercial programs, this statement means that it works, but is intolerably slow! ECU's sky drawing routines are written almost entirely in integer math, thus operate quickly with or without the math processor. During development, the author's computer did not have a math co-processor. I have one now.

The math processor, however, does dramatically speed up local horizon, planet, sun, moon, and comet orbit calculations.

## 1.2 Installation Instructions

ECU is distributed as one file (**ECUREG.EXE**) in self uncompressing format. The compressed file contains the files listed below under the headings "SHAREWARE VERSION" and "REGISTERED VERSION". The SHAREWARE

version is also distributed as a self uncompressing file (**ECUSHARE.EXE**) containing the files listed below under the heading "SHAREWARE VERSION". If you ordered the ENHANCED STELLAR DATABASE, you will have received two additional disks.

### SHAREWARE VERSION

ECU.EXE	- the main executable program file
ECU.CFG	- the default configuration file
BOUNDS.ECU	- constellation boundaries data file
YBSC1.ECU	- the main Yale Bright Star file
SAC1.ECU	- the main "deep sky" object file
CONS.ECU	- the constellation data file
LABELS.ECU	- the text labels data file
LOCATION.ECU	- the geographic location data file
REGISTER.WRI	- the ECU registration form in <i>Windows Write</i> format
MANUAL.WRI	- this manual in <i>Windows Write</i> format
VENDOR.TXT	- a file containing information for commercial disk vendors and BBS's

### REGISTERED VERSION

ALL ABOVE FILES PLUS:

YBSC2.ECU	- the secondary Yale Bright Star file
SAC2.ECU	- the secondary "deep sky" object file
PTERMS.ECU	- the orbital terms used for high accuracy calculations
PINDEX.ECU	- the index file for PTERMS.ECU

### ENHANCED STELLAR DATABASE VERSION

ALL ABOVE FILES PLUS:

SAO1.ECU	- the primary Smithsonian Astrophysical Observatory star file
SAO2.ECU	- the secondary Smithsonian Astrophysical Observatory star file

Installation of ECU is straight forward. The example below assumes that your hard disk is drive 'C', and your floppy disk is drive 'A'. You can install ECU from DOS or from a "DOS Window" within Windows 3.

### TYPE

1.	Log to your hard disk:	<b>C: &lt;return&gt;</b>
2.	Make a directory to store ECU:	<b>MD \ECU &lt;return&gt;</b>
3.	Change to the ECU directory:	<b>CD \ECU &lt;return&gt;</b>
4.	Install the ECU program disk in drive 'A'	
5.	Extract the files from ECUREG.EXE:	<b>A:\ECUREG&lt;return&gt;</b>
6.	If you don't have the enhanced stellar database go to step 11.	
7.	Install the ECU SAO1 disk in drive 'A'	
8.	Extract the files from SAO1.EXE	<b>A:\SAO1&lt;return&gt;</b>
9.	Install the ECU SAO2 disk in drive 'A'	
10.	Extract the files from SAO2.EXE	<b>A:\SAO2&lt;return&gt;</b>
11.	Start or Exit Windows:	<b>WIN &lt;return&gt;</b> or <b>EXIT &lt;return&gt;</b>
12.	Start the "File Manager"	<b>use the mouse</b>

13. Open the ECU directory such that the ECU.EXE file is visible.
14. Arrange the screen so that ECU.EXE and a suitable program group in the "Program Manager" are both visible.
15. Drag ECU.EXE from the "File Manager" to the "Program Manager". A colourful Icon should appear.
16. Proceed to section 1.3: Starting ECU.

If your hard disk space is limited, the space used by ECU can be reduced by deleting several files. If you are not interested in the spectral type or SAO designation of stars in the ENHANCED STELLAR DATABASE, you can delete the file "SAO2.ECU". This will reduce ECU's hard disk space requirement by slightly less than two megabytes. The file "YBSC2.ECU" can be deleted if the extended information in the Yale Bright Star catalogue is not desired. This will save an additional 500 kilo-bytes. ECU will automatically detect the absence of these files and adjust its operation accordingly.

## 1.3 Starting ECU

ECU is started by double-clicking the ECU Icon. Loading ECU typically takes a few seconds, however, the SHAREWARE version takes somewhat longer the first time it is started. This is because the file MATH.ECU needs to be created. This file is used by ECU to speed up its sky drawing functions. It is not distributed in the SHAREWARE version so as to reduce the "download" time (and therefore the cost) of ECU from bulletin boards. Subsequent startups will occur more quickly.

Before the "main window" appears, several data files, plus the configuration file are loaded into memory. If any problem is encountered while loading ECU (due to bad or missing files, not enough memory, etc.), a small dialog box displaying a descriptive message is displayed on the screen. Pressing 'OK' will return control to Windows 3.

If all is successful, the opening screen will appear greeting the user with a colourful display of the constellation of ORION similar to that shown on the cover of this manual.

At this time, only one copy of ECU can be running at any one time. If the user attempts to run a second copy of ECU, a small dialog box will appear describing the problem.

By default, ECU always uses the configuration file "ECU.CFG" located in the current directory. If a file name is specified on the command line, ECU uses the specified file. This is useful for setting up ECU 'icons' to quickly bring up saved astronomical events.

I suggest you read sections 2. and 3. next, which introduce the operation of the program, and address all of the menu selections. If you just want to explore, that's fine, too. I think you will find ECU quite intuitive. Section 4. then describes the built-in databases.

## 2. Introduction

This section assumes that ECU is installed and is running. Mouse operations are integral to the operation of ECU, and will be described in Section 2.3. The on-screen controls, such as the check boxes and scroll bars will be described in Section 2.4, the keyboard quick-keys are described in Section 2.5, and the menu selections in Section 3. But first, the on-screen status displays and sky display area will be described.

### 2.1 The Status Display

The left portion of the ECU window comprises the status display area. This area contains the following items:

- a) **Geographic Location** - the top line shows the city where the observer is located. If a city was not selected (but rather a specific latitude/longitude was entered), the message "By Lat/Long" will be displayed. Immediately below, the latitude (Lat) and longitude (Long) of the observer is displayed as degrees and minutes. Positive latitudes are North of the equator and positive longitudes are West of the Greenwich meridian. To set your geographic location, see section 3.3.2, which describes the "Set -> Geographic Location" menu selections.
- b) **Local Mean Time (LMT)** - contains the date and time of the local civil time. The date is always in the format year/month/date. The time is either displayed as hh:mm in 24 hour time or hh:mmpm in am/pm format. See section 3.3.1.4.

- c) **Universal Time (UTC)** - contains the universal date and time (that of the Greenwich meridian). The date is always in the format year/month/date. The time is always displayed as hh:mm in 24 hour time format.
- d) **Right Ascension (RA)** - contains the right ascension of the center of the sky display. It is formatted in hours and minutes as hh:mm.m.
- e) **Declination (Dec)** - contains the declination of the center of the sky display. It is formatted in degrees and minutes as +dd mm'.
- f) **Azimuth (Azim)** - contains the azimuth of the center of the sky display. The azimuth is the angle, in degrees and minutes, from the Northern horizon towards the East at the current Date and Time and Geographic Location.
- g) **Altitude (Alt)** - contains the altitude of the center of the sky display. The altitude is the angle, in degrees and minutes, measured vertically from the horizon at the current Date and Time and Geographic Location.
- h) **Field Size (Field)** - contains the number of vertical degrees currently shown in the sky display. The minimum field size is 2 degrees and the maximum is about 60 degrees.
- i) **Magnitude (Mag)** - contains the minimum magnitude for which stars are displayed in the sky display. This number is usually the same as that set in the "Set -> Magnitude Limits..." menu selection, however to keep the sky drawing speed fast, the maximum magnitude of stars displayed changes with the field size. This ranges from magnitude 4.0 for fields larger than 120 degrees to magnitude 8.5 for field sizes from 10 to 15 degrees. See section 3.4.2, which describes the "Set -> Magnitude Limits..." menu selection.
- j) **Animation Time Step** - contains the size of the time step used by the animation mode in minutes, hours, days, months, or years. If an arbitrary time step has been entered, the word "Manual" will be shown.

## 2.2 The Sky Display

The right portion of the ECU window is the sky display area. The sky display area displays celestial objects using one of three "projections". These three projections were selected for the speed of their calculation, however there is some distortion at the limits of their usefulness.

When displaying the sky from -45 to +45 degrees Declination and a field size of 60 degrees or less, a simple **modified-Mercator** projection is used. This projection causes the objects at high Declinations to be distorted (spread-out), most noticeable in constellations like Ursa Major (the big dipper). This is the same distortion that makes Canada appear much larger than the United States on world maps with similar projections (Canada is only about 10% larger).

When displaying the sky either North of +45 or South of -45 degrees in Declination and a field size of 60 degrees or less, the **Zenithal Equidistant Projection** is used. This projection is quite good, but does spread out objects a bit at low Declinations.

When displaying the sky with field sizes larger than 60 degrees, an **Orthogonal Projection** is used. This projection is essentially a sphere (like the Earth) viewed from infinity. It can show an entire hemisphere of the sky at once, but suffers from distortion at the edges of the field.

With all three projections, the North Celestial Pole is always up (South is down) and East is to the right (West is to the left). The local horizon is **not** parallel to the bottom of the screen, but rather is tilted a varying amount dependent on the latitude entered. A future version of ECU will support a "Local Horizon" display mode.

The objects and items displayed in the sky display area are listed below. Each will be discussed in detail in sections 3. and 2.4 by the specific menu selection or screen resource which controls their operation.

- a) **Grid** - the coordinate grid helps illustrate the sky projections just described. Lines of Right Ascension are drawn every hour (coarse grid) or every 20 minutes (fine grid). Lines of Declination are drawn every 10 degrees (coarse grid) or every 5 degrees (fine grid).

- b) **Stars** - stars are displayed as varying sized dots according to the star's brightness. The larger the dot, the brighter the star.
- c) **Lines** - there are many lines displayed by ECU. These include the constellation lines, constellation boundary lines, horizon line, and ecliptic line. Markers are also displayed at the Zenith (the overhead point) and the North and South poles.
- d) **Labels** - there are text labels displayed for solar system objects, bright stars names, Messier objects, constellation names, and labels for the coordinate grid, ecliptic and horizon lines, and markers.
- e) **Solar System objects** - the planets, sun, moon, and comets are displayed. The sun and moon are displayed to their correct size and the phase of the moon is shown. Planets are displayed as either a point or by their standard symbol. Comets are displayed as points. Comets are not available in the SHAREWARE VERSION of ECU.
- f) **Deep sky objects** - deep sky objects are displayed in six different categories. These are Galaxies, Open Clusters, Globular Clusters, Bright Nebulae, Planetary Nebulae, and Other; each displayed using a different symbol.

## 2.3 Mouse Operations

The mouse forms a vital part of the ECU user interface and has many uses from within ECU. The cursor (the shape of the mouse pointer) is used to inform the user of how the mouse is currently being used. If it is a cross-hair, it is used for selecting a window, identifying an object, centering, or measuring an angle. The cursor is always a cross-hair while in the sky display area. If it is an arrow, it is used for operating the scroll bars or buttons.

If it is the planet Saturn, ECU is busy computing solar system positions. If it is an hour-glass, ECU is busy performing some other task; usually drawing the sky display.

Each mouse button will be described separately in the next two sections.

### 2.3.1 Left Mouse Button

The left mouse button, while the cursor is in the sky display area, is used for the following functions.

- a) **Select an object** - if the left mouse button is pressed (and released) within a few pixels of the center of an object, a dialog box, called the "Identify Object" dialog box, will appear identifying and describing the object. Section 5. details the contents of the "Identify Object" dialog box. A cross-hair will appear on the screen identifying the object currently selected. The dialog box is always placed in the diagonally opposite corner from the object selected, so that it doesn't cover the object selected. The dialog box can, of course, be moved about the screen as the user wishes.

If more than one object is in the vicinity, the "Next" button can be pressed to update the dialog box with new information for the next object. The "Precess" button precesses the objects coordinates to the epoch of the current date. The "Show" button will show a picture of the object (if one exists) on the screen.

The dialog box can be terminated in four ways. If the "Quit" button is pressed, the dialog box will terminate immediately. If another object is selected, the current dialog box will be replaced with a new one. If the left mouse button is pressed while the cursor is not near an object, the dialog box will terminate. Finally, the <ESC> key can be pressed.

For more information about the "Identify Object" dialog box, see Section 5.

- b) **Zoom a window** - the second function performed by the left mouse button is its ability to draw a rectangle on the screen which is used to re-position and re-scale the sky display. The rectangle is drawn by positioning the mouse at one corner, drag  
ging the mouse (with the left mouse button pressed) to another corner, and then releasing the button. The center of the



rectangle defines the new display center and the vertical height is used to scale the display.

### 2.3.1 Right Mouse Button

The right mouse button, while the cursor is in the sky display area, is used for the following functions.

- a) **Center the mouse position** - if the right mouse button is pressed (and released), the current mouse position will become the center of the sky display at the current scale. This feature is very useful for quickly "panning" about the sky.
- b) **Measure an angle** - the second function performed by the right mouse button is its ability to measure angles on the sky. Angles are measured by positioning the mouse at one location, dragging the mouse (with the right mouse button pressed) to another location, and then releasing the button. A dialog box will appear which displays the angular measure between the two points in degrees.

### 2.4 On-Screen Controls

The on-screen controls include the scroll bars, zoom buttons, check boxes, and time step arrows and buttons. Each is described below:

- a) **Scroll Bars** - Two scroll bars are used to rapidly move the center of the sky display about the celestial sphere. The scroll bars are used in two modes as controlled by the menu selection described in section 3.4.10.
  - 1) The vertical bar is used to change the Declination. +90 degrees is at the top; -90 degrees is at the bottom. Pressing the end arrows will move the pointer (and the sky display) by one degree and pressing along the bar will move the pointer by 10 degrees. The horizontal bar is used to change the Right Ascension. 23 hours 59 minutes is at the left; 0 hours is at the right. Pressing the end arrows will move the pointer by 4 minutes and pressing along the bar will move the pointer by one hour. When sliding the scroll bars by dragging the pointer, observe at the Right Ascension and Declination displays to know when to stop.
  - 2) The vertical bar is used to change the Altitude with reference to the local horizon. +90 degrees is at the top (the Zenith); -90 degrees is at the bottom (the Nadir). Pressing the end arrows will move the pointer (and the sky display) by one degree and pressing along the bar will move the pointer by 10 degrees. The horizontal bar is used to change the Azimuth with reference to the local horizon. 0 degrees (North) is at the left; 358.5 degrees is at the right. Pressing the end arrows will move the pointer by 1.5 degrees and pressing along the bar will move the pointer by 15 degrees. When sliding the scroll bars by dragging the pointer, observe at the Azimuth and Altitude displays to know when to stop.
- b) **Zoom buttons** - the zoom buttons, identified as "Z-IN" and "Z-OUT", are used to change the scale of the sky display. Each press of the respective button changes the scale by a factor of two.
- c) **Check boxes** - the six check boxes: Stars, Deep Sky, Solar System, Grid, Lines, and Labels are used to toggle whether the respective item is displayed in the sky display. Note that when operating with graphics boards providing less than 350 pixels in vertical resolution, only the Stars and Deep Sky check boxes are available.
- d) **Time step arrows and buttons** - the time buttons "+" and "-" are used to change the current time by the amount shown at the immediate left. Pressing the black arrows causes the amount at which the time changes to be altered in steps from a minimum of 1 minute to a maximum of 4 years.
- e) **Speed buttons** - the boxes in the status area, which are used to display the current settings of parameters ranging from the Geographic Location to the Animation Time Step (see section 2.1), are also used to provide quick access to the menu items which control the respective parameter. When the left mouse button is pressed while the mouse is within one in the boxes cause the appropriate dialog box to "pop-up". For example, the left mouse button is pressed within the "Mag" box, the "Magnitude Limits..." dialog box will pop-up.

### 2.5 Keyboard Quick Keys

Most of the functions of ECU can be operated from the keyboard, but the mouse interface is much more efficient. However, there are some key combinations that do speed up access to some functions. These are listed below:

- a) **Alt-S** - equivalent to the menu item: File -> Save
- b) **Alt-A** - equivalent to the menu item: File -> Save As...
- c) **Alt-E** - equivalent to the menu item: File -> Exit
- d) **Alt-F4** - equivalent to the menu item: File -> Exit
- e) **Alt-Backspace** - equivalent to the menu item: Edit -> Undo
- f) **Alt-T** - equivalent to the menu item: Set -> Time -> Set Local Time...
- g) **Alt-U** - equivalent to the menu item: Set -> Time -> Use System Time
- h) **Alt-L** - equivalent to the menu item: Set -> Geographic Location -> By Latitude/Longitude...
- i) **Alt-C** - equivalent to the menu item: Set -> Geographic Location -> By City/Town...
- j) **Alt-M** - equivalent to the menu item: Field -> Magnitude Limits...
- k) **Alt-O** - equivalent to the menu item: Field -> Object Selection...
- l) **Alt-P** - equivalent to the menu item: Field -> Planets...
- m) **Escape** - stops the execution of animation mode
- n) **Alt-Z** - zoom the sky display to full zoom (180 degrees)
- o) **Shift-M** - centers the sky display on the Moon
- p) **Shift-S** - centers the sky display on the Sun
- q) **N** - centers the sky display on the local northern horizon
- r) **S** - centers the sky display on the local southern horizon
- s) **E** - centers the sky display on the local eastern horizon
- t) **W** - centers the sky display on the local western horizon
- u) **Z** - centers the sky display on the local zenith (overhead point)

### 3. Menu Selections

The menu selections control most of the features of ECU and are divided into seven categories as listed below. Each is described in detail in the identified sections:

- a) **File** - the file menu handles the loading and saving of the configuration settings of ECU (see section 3.1).
- b) **Edit** - edit allows the last operation to be nullified (see section 3.2).
- c) **Set** - the set menu allows the time, geographic location, solar system calculation settings, atmospheric refraction flag, comet orbits, sky display colours, and sky drawing mode to be adjusted (see section 3.3).
- d) **Field** - the field menu controls if and how the stars, deep sky objects, planets, sun/moon, grid, lines, and labels are displayed. It also allows for various zoom settings (see section 3.4).
- e) **Center** - the center menu allows many ways to set the center of the sky display. These ways include centering on a specified Right Ascension/Declination, a constellation, a bright star, a Messier object, a Solar System object, a point on the local horizon, or by a text search of the databases (see section 3.5).
- f) **Animation** - the animation menu controls the various features of the animation mode (see section 3.6).
- g) **About** - the about menu lists the program credits, the version number, etc. (see section 3.7).

Many of the common menu items have "short cut" keyboard keys to allow quick access to their features. The keys used are identified by an underline under the key used. The Alt key is to be pressed in conjunction with the identified key. Also, some menu items identify their keyboard equivalent to the right in their menu item.

#### 3.1 File Menu

The **File** menu allows the configuration settings of ECU to be loaded (opened) and saved. Virtually every setting in ECU is stored in the configuration file. This allows ECU to be "set up" for a particular astronomical event and this event saved to a configuration file for later quick retrieval.

The file menu also provides access to setup printers and to print high-quality star charts of the current sky display.

##### 3.1.1 Open...

The **Open...** menu selection presents a dialog box allowing a new configuration file selected, then subsequently

loaded. It defaults to file names with the extension ".cfg".

I will not detail the operation of this dialog box, since it is identical to every other MS-Windows application that has an Open... function.

### 3.1.2 Save

The **Save** menu selection saves the current configuration settings to the current configuration file name. The current file name is always displayed on the ECU Window title. The keyboard equivalent to this menu selection is **Alt-S**.

### 3.1.3 Save As...

The **Save As...** menu selection saves the current configuration settings to the file specified by the file name selected in the dialog box presented. I will not detail the operation of this dialog box, since it is identical to every other MS-Windows application that has a Save As... function. The keyboard equivalent to this menu selection is **Alt-A**.

### 3.1.4 Printer Setup...

The **Printer Setup...** menu selection presents a dialog box allowing the user to select and setup a printer to be used by ECU. The dialog box contains a drop down pick list and three buttons. The printer to be used is selected from the pick list. To change the default settings for the selected printer, press the "Setup..." button. This will activate the printer's setup dialog box where such items as the printer's resolution and the page size and orientation (portrait or landscape) can be set. All changes to the printer's settings remain in effect until ECU is terminated.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the printer's settings, is accomplished by pressing 'Cancel'.

### 3.1.5 Print Chart

The **Print Chart** menu selection prints a high-quality chart of the sky display on the printer selected and setup in **Printer Setup...**. The chart is printed with the same settings used to draw the sky display. The chart is printed in two formats. In either format, a title box is printed at the bottom of the page containing the geographic location, the universal and local date and time, the center of the chart as the right ascension and declination, the center of the chart as the azimuth and altitude, and the height of the field.

If the printer is set in portrait mode (or, if the height of the paper is larger than its width), a legend box is drawn above the title box. If the printer is set in landscape mode (or, if the width of the paper is larger than its height), a legend box is drawn on the right side of the page. This legend box shows the stellar magnitude limit and the star symbols used, the deep sky magnitude limit and the deep sky symbols used, and an area for your notes.

A sample chart printed in Landscape mode on an Okidata OL400 laser printer is found at the back of this manual. This version of ECU is the first to contain chart printing. Many improvements will be included in future updates. See Section 6. for details.

If you have any difficulties printing charts, I would like to hear from you. Although ECU has been tested with as many printers as I could access, there are bound to be a few printers that may cause problems. Please send me the symptoms, a sample chart, your ECU.CFG file, and the type of printer and Windows driver (and version) that was used.

### 3.1.6 Exit

The **Exit** menu selection is used to exit ECU. If the configuration settings have changed, a message box appears asking to user to specify if the settings are to be saved to the current file name. Pressing "Yes" (or the enter key) will save the configuration settings to the current file name and exit ECU. Pressing "No" will exit ECU without saving the configuration settings. Pressing "Cancel" will return control to ECU.

ECU can also be exited by "double-clicking" on the Control-menu box or by selecting "Close" in the window's system menu. The keyboard equivalent to this menu selection is **Alt-E** or **Alt-F4**.

## 3.2 Edit Menu

The **Edit** menu currently has only one entry: **Undo**. The Undo menu selection nullifies the last operation. This is very useful when you have made a "slip of the mouse" and wish to get back to where you were. The keyboard equivalent to this menu selection is **Alt-Backspace**.

## 3.3 Set Menu

The **Set** menu allows the time, geographic location, Solar System calculation settings, atmospheric refraction setting, comet orbits, sky colours, and sky drawing mode to be adjusted. Each is described in the sections below.

### 3.3.1 Time

The time can be set in one of three formats: local civil time, Universal time (UTC), set to your pc's system clock (using local civil time). The current time format used is identified in the **Time** menu selections sub-menu, by a check mark in front of the current mode. The following sections describe the time settings.

#### 3.3.1.1 Enter Local Time

The **Enter Local Time** menu selection presents a dialog box allowing the user to enter the year, month, date, hour, and minute in local time format. The year can be from 1000 to 3000 AD and the hour must be in 24 hour format. The time is always initialized to the current time.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the time, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

This menu selection can also be activated by pressing the left mouse button while the mouse is in either of the boxes which display the local mean date and time (LMT) in the ECU status display area. The keyboard equivalent to this menu selection is **Alt-T**.

#### 3.3.1.2 Enter Universal Time

Entering the Universal time is accomplished identically to entering the local time. This menu selection can also be activated by pressing the left mouse button while the mouse is in either of the boxes which display the universal date and time (UTC) in the ECU status display area.

#### 3.3.1.3 Use System Time

Selecting **Use System Time** causes ECU's local time to become synched to your pc's system clock. This will cause the sky to update automatically once per minute, therefore simulating the actual sky's movements. The keyboard equivalent to this menu selection is **Alt-U**.

#### 3.3.1.4 Set Time to System Time

Selecting **Set Time to System Time** causes ECU's time base to be set to your pc's system clock. Unlike the selection **Use System Time**, the sky will not update automatically thereafter.

#### 3.3.1.5 Local Time Format

The local mean time (LMT) display in the status area is displayed in either 24 hour or am/pm format. The **Local Time Format** menu selection is a sub-menu of **AM/PM** and **24 Hour** selections, each selection setting the respective format. The current format is identified by a 'check mark'.

#### 3.3.1.6 Daylight Savings

The **Daylight Savings** menu selection toggles whether the current local time is to be interpreted as a daylight savings time. It is used by ECU to convert from local time to Universal time. If a 'check mark' is present, daylight savings mode is enabled. If ECU is using the pc's system clock and the daylight savings time 'check mark' is present, the pc's time should be set to the daylight savings time.

### 3.3.2 Geographic Location

The **Geographic Location** menu selection provides a sub-menu containing two methods of entering a location on the Earth's surface. These are **By Latitude/Longitude** and **By City/Town**.

#### 3.3.2.1 By Latitude/Longitude

The **By Latitude/Longitude** menu selection presents a dialog box allowing the user to enter the latitude, longitude, and time zone of the location used in the sky display calculations. The latitude is entered as degrees (North is positive, South is negative) and minutes. The longitude is also entered as degrees (West of the prime meridian is positive, East is negative) and minutes. The time zone is entered in hours West of UTC (the time of the Greenwich meridian; enter a negative for the Eastern hemisphere). The location is always initialized to the current location.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the location, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

This menu selection can also be activated by pressing the left mouse button while the mouse is in either of the boxes which display the current latitude and longitude in the ECU status display area. The keyboard equivalent to this menu selection is **Alt-L**.

#### 3.3.2.2 By City/Town

The **By City/Town** menu selection presents a dialog box allowing the user to select the location from a set of pre-defined locations. A list box is presented containing the available list. The user is to select the desired location, then exit the dialog box.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the location, is accomplished by pressing 'Cancel'.

This menu selection can also be activated by pressing the left mouse button while the mouse is in the box which displays the current city/town at the top the ECU status display area. The keyboard equivalent to this menu selection is **Alt-C**.

If your location is not in the list of available locations, you can use a text editor (the Windows **NotePad** will do fine) to edit the file LOCATION.ECU. The file format is quite simple, as shown by the sample entries below:

```
49.0 59.0 3.5 Corner Brook NFLD
53.3 60.1 4 Goose Bay, LAB
47.5 52.9 3.5 St. John's NFLD
46.1 59.8 4 Sydney NS
```

The first three entries, which are separated by spaces, are the latitude (decimal degrees North of the Equator), longitude (decimal degrees West of the Prime meridian), and time zone (hours West of UTC). The fourth entry is the name of the location. The order of lines in the file does not matter since ECU sorts the file into alphabetical order when it is loaded.

### 3.3.3 Solar System

The Solar System menu selection provides a sub-menu allowing several calculation options pertaining to the Solar System to be changed. A 'check mark' in front of a menu item indicates that it is enabled. Each menu item is described below.

For maximum accuracy, set all check marks to their checked state. This is very important when simulating eclipses or other astronomical phenomenon where the observer's geographic location is important.

### **3.3.3.1 High Accuracy Calculations**

This menu selection controls the precision of the solar system calculations. The high accuracy calculations are not available when using the SHAREWARE VERSION of ECU.

### **3.3.3.2 Precess to Sky Display**

This menu selection controls whether the Solar System object positions and the horizon line are to be adjusted (due to the effect of precession of the Earth's axis of rotation) to match the J2000.0 coordinates used by the sky display.

### **3.3.3.3 Nutation**

This menu selection controls whether the Solar System object positions (except the comets) are to be corrected for the effects of Nutation. Nutation is at maximum, a 9 arc-second wobble in the precession circle primarily caused by the gravitational pull of the Moon.

Nutation can only be calculated when the High Accuracy Calculations selection is enabled.

### **3.3.3.4 Aberration**

This menu selection controls whether the Solar System object positions (except the comets) are to be corrected for the effects of Aberration. Aberration is the apparent displacement of the position of an object due to the finite speed of light. This effect is due to the rotation of the Earth and the motion of the Earth through the solar system.

The effect of Aberration can only be calculated when the High Accuracy Calculations selection is enabled.

### **3.3.3.5 Light Travel Time**

This menu selection controls whether the Solar System object positions (except the Moon) are to be corrected for the effects of the Light Travel Time. The Light Travel Time correction recognizes that the observer sees an object at where it used to be in the past.

Light Travel Time corrections can only be calculated when the High Accuracy Calculations selection is enabled.

### **3.3.3.6 Observer's Parallax**

This menu selection controls whether the Solar System object positions (except the comets) are to be corrected for the effects of the Observer's Parallax. The Observer's Parallax is the effect of an apparent shift of an objects position for observers located at different locations on the Earth. This effect is what causes the Solar Eclipses and Occultations of the Moon to be only observable from certain locations on the Earth's surface.

It is very important that this selected be enabled when simulating solar eclipses or other astronomical phenomenon where the observer's geographic location is important.

### **3.3.4 Atmospheric Refraction**

This menu selection controls whether the local horizon, Azimuth and Altitude displays, and Rise/Set calculations are to be corrected for the effects of Atmospheric Refraction. Atmospheric Refraction causes an object to appear higher in the sky that it actually is. The bending (or refraction) of light as it passes through the Earth's atmosphere causes this effect.

### **3.3.5 Define Comet Orbit**

The **Define Comet Orbit** menu selection provides a sub-menu of the six comets which can be defined. Each selection is identical except for the comet number.

Each sub-menu selection presents a dialog box allowing the orbital elements of a comet to be entered. The following items can be entered.

- a) **Comet Name** - a textual name that can be displayed next to the comet in the sky display.
- b) **Date of Perihelion** - the date of perihelion can be entered as either decimal years or as year, month, and decimal days. If the month is set to zero, the decimal years are used and the month and date are ignored. If the month is valid (1 to 12), the year, month, and date are used.
- c) **Perihelion Distance ( $q$ )** - the distance of the comet to the Sun in astronomical units (AU) at Perihelion.
- d) **Eccentricity ( $e$ )** - the eccentricity of the comet's orbit from 0 to 2.
- e) **Argument of Perihelion ( $\varpi$ )** - the argument, in degrees, of the perihelion.
- f) **Longitude of Ascending Node ( $\Omega$ )** - the longitude, in degrees, of the ascending node.
- g) **Inclination of Orbit ( $i$ )** - the inclination of the orbit in degrees.
- h) **Epoch of the Elements** - the epoch of the elements, either B1950.0 or J2000.0.
- i) **Magnitude Constants** - the magnitude constants H and G, are used to estimate the brightness of the comet. Each comet has a different set of constants. Comet brightness predictions are notoriously extremely unreliable.
- g) **Enable Comet** - this flag enables the comet for display.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the comet orbital elements, is accomplished by pressing 'Cancel'.

If a comet has a name and is 'enabled', it will be subsequently be referred to in the menus by its name instead of just "Comet 1", etc.

### 3.3.6 Set Sky Colours

The **Set Sky Colours...** menu selection presents a dialog box allowing the user to set the colours used to draw the sky display. The dialog box contains four "radio" buttons, one "combo" box, and three scroll bars. When drawing the sky display ECU subdivides the drawing into 26 different elements. These include elements such as constellation lines, the sun, galaxies, etc.

The radio buttons are mutually exclusive, such that only one can be active at any one time. The "Colour" radio button is the mode where the colour of each sky display drawing element can be individually set as described below. The "White on Black Background" mode causes the entire sky display to be drawn in white with a black background. The "Black on White Background" mode causes the entire sky display to be drawn in black with a white background. This mode is especially useful for "pasting" the display into other Windows program for further manipulation. Either of these two modes may also be useful when ECU is used on laptop computers with LCD screens.

The "Red" mode causes the entire screen (including the system colours, which will affect all other Windows applications running on your system) to appear in black and shades of red. When ECU is being used in the field or in an observatory, this mode will help maintain the user's dark adaptation. When exiting ECU, all of the system colours are restored to their original state.

The colours of individual sky display drawing elements are controlled by first selecting the element from the "drop down pick list" in the top left of the dialog box. Pressing the down arrow will cause a "pick list" to be displayed with a scroll bar on the right hand side. Using the scroll bar, simply select the drawing element whose colour you wish to change with the mouse. The three horizontal scroll bars on the right side of the dialog box will be set to the colour of the selected drawing element and the actual colour is shown in a box beneath the scroll bars.

In Windows, colours are represented by their equivalent red, green, and blue proportions. To change a colour drag any or all of the three scroll bars until the desired colour is shown. The number of different colours that can be produced varies considerably (ranging from 16 to 16 million colours) with the graphics card and its associated driver.

Pressing 'OK' exits the dialog box and activates the new colour settings. Pressing 'Cancel' exits without making any changes.

### 3.3.7 Set Drawing Mode

The **Sky Drawing Mode** menu selection provides a sub-menu allowing the mode in which ECU uses to draw the sky display. If 'Fast Update' is selected, the sky display will update essentially instantaneously. ECU performs all the necessary calculations and drawing functions to the computer's memory in advance, then updates the sky display all at once.

If 'Continuous Drawing' is selected, the sky display will update sequentially as each element is calculated and drawn. This mode may enable the sky display to update faster than the 'Fast Update' mode on some "accelerated" graphics boards that have become very popular lately. A 'check mark' marks the current setting.

## 3.4 Field Menu

The **Field** menu controls various parameters pertaining to the sky display. Each menu selection is described separately in the following sections.

### 3.4.1 Display

The **Display** menu selection provides a sub-menu allowing the user to toggle the display of stars, deep sky objects, solar system objects, the grid lines, lines and labels on the sky display. This menu selection duplicates the on-screen check boxes. The current state of each display setting indicated by a 'check mark' in front of the menu item.

### 3.4.2 Magnitude Limits...

The **Magnitude Limits...** menu selection presents a dialog box allowing the user to set the limiting magnitude for stellar and deep sky objects. The magnitude is set by dragging the scroll bars to the desired magnitude as displayed immediately below each scroll bar.

The actual stellar limiting magnitude is dependent on the field size, however, the setting here sets the upper limit. If the deep sky magnitude limit is set to 20, all objects will be displayed, even those whose magnitude is unknown.

Pressing 'OK' exits the dialog box and activates the new magnitude limits. Pressing 'Cancel' exits without making any changes.

This menu selection can also be activated by pressing the left mouse button while the mouse is in box which displays the current Magnitude Limit in the ECU status display area.

### 3.4.3 Object Selection...

The **Object Selection...** menu selection presents a dialog box allowing the user to select which types of deep sky objects are displayed. The dialog box has 7 check boxes; one for each of Galaxies, Globular Clusters, Open Clusters, Bright Nebulae, Planetary Nebulae, Other, and Unknown Magnitudes. If the check box of the respective object type is true, that type will be displayed (if deep sky objects are also 'turned on').

Note that the 'Unknown Magnitude' type is provided to allow the user to 'turn off' the objects whose magnitude is unknown. This makes the display less cluttered by not displaying hundreds (or thousands) of objects that are likely to be quite faint.

Pressing 'OK' exits the dialog box and activates the new object selections. Pressing 'Cancel' exits without making any changes.

### 3.4.4 Planets...

The **Planets...** menu selection presents a dialog box which allows the user to control various display parameters for the eight planets. The three entries for each planet include a check box indicating if the respective planet is displayed, a set of radio buttons which determines if it is displayed as either a point or as the planet's symbol, and a check box indicating if the



planet's name is also displayed.

Pressing 'OK' exits the dialog box and activates the new planets settings. Pressing 'Cancel' exits without making any changes.

### 3.4.5 Sun

The **Sun** menu selection toggles whether or not the Sun is displayed on the sky display. If marked by a 'check mark', the Sun will be displayed (assuming the Solar System objects are also 'turned on').

### 3.4.6 Moon

The **Moon** menu selection toggles whether or not the Moon is displayed on the sky display. If marked by a 'check mark', the Moon will be displayed (assuming the Solar System objects are also 'turned on').

### 3.4.7 Grid

The **Grid** menu selection provides a sub-menu allowing the resolution of the coordinate grid to be set. If 'Fine' is selected, the grid will mark every 20 minutes in Right Ascension and every 5 degrees in Declination. If 'Coarse' is selected, the grid will mark every 1 hour in Right Ascension and every 10 degrees in Declination. A 'check mark' marks the current setting.

### 3.4.8 Lines/Points

The **Lines/Points** menu selection provides a sub-menu allowing the user to toggle the display of lines and points on the sky display. These include the constellation lines, constellation boundary lines, ecliptic line, horizon line, zenith point, and celestial pole points. The current state of each line/point is indicated by a 'check mark' in front of the menu item.

### 3.4.9 Labels

The **Labels** menu selection provides a sub-menu allowing the user to toggle the display of text labels on the sky display. These include the constellation labels, bright star labels, Solar System labels, Messier labels, horizon line/zenith point labels (N,S,E,W, etc.), and ecliptic point labels (VE - vernal equinox, SS - summer solstice, etc.).

An additional selection labelled "Draw Labels When Zoomed Out" controls whether the major labels are displayed when the field size is larger than 60 degrees in height. The purpose of this selection is to reduce the text "clutter" when "zoomed out", while maintaining the desired detail when "zoomed in".

The current state of each label is indicated by a 'check mark' in front of the menu item.

### 3.4.10 Scroll Bars

The **Scroll Bars** menu selection provides a sub-menu allowing the mode of the scroll bars to be set. If 'RA/Dec' is selected, the scroll bars are used to move about the celestial sphere using Right Ascension and Declination coordinates. If 'Azim/Alt' is selected, the scroll bars are used to move about the local sky display using Azimuth and Altitude coordinates. A 'check mark' marks the current setting.

### 3.4.11 Flip Horizontal

The **Flip Horizontal** menu selection toggles whether or not the sky display is drawn as a mirror image (flipped left to right). If marked by a 'check mark', the sky display will be flipped. This selection is useful by itself to simulate what the sky will look like through a telescope which produces an upright, but reversed image such as a refractor or Schmidt-Cassegrain with a star diagonal installed. Used in conjunction with **Flip Vertical**, the sky display is drawn upside-down and reversed left to right, to simulate the view through a Newtonian telescope or to make the sky appear more realistic to those users located in the Earth's southern hemisphere.

### 3.4.12 Flip Vertical

The **Flip Vertical** menu selection toggles whether or not the sky display is drawn as a upside-down (flipped top to bottom). If marked by a 'check mark', the sky display will be flipped. If this selection is used in conjunction with **Flip Horizontal**, the sky display is drawn upside-down and reversed left to right, to simulate the view through a Newtonian telescope or to make the sky appear more realistic to those users located in the Earth's southern hemisphere.

### 3.4.13 Field Size...

The **Field Size...** menu selection presents a dialog box allowing the user to enter the vertical size, in degrees, of the ECU sky display. The valid range is 2 to 180 degrees in integer divisions.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

This menu selection can also be activated by pressing the left mouse button while the mouse is in box which displays the current Field Size in the ECU status display area.

### 3.4.14 Zoom In Full

The **Zoom In Full** menu selection causes the ECU sky display to zoom in to the minimum allowable field size, which is 2 degrees in height.

### 3.4.15 Zoom To 15 Degrees

The **Zoom To 15 Degrees** menu selection causes the ECU sky display to zoom a field size, which is 15 degrees in height.

### 3.4.16 Zoom To 45 Degrees

The **Zoom To 45 Degrees** menu selection causes the ECU sky display to zoom a field size, which is 45 degrees in height.

### 3.4.17 Zoom To 90 Degrees

The **Zoom To 90 Degrees** menu selection causes the ECU sky display to zoom a field size, which is 90 degrees in height.

### 3.4.18 Zoom Out Full

The **Zoom Out Full** menu selection causes the ECU sky display to zoom out to the maximum allowable field size, which is 180 degrees in height.

## 3.5 Center Menu

The **Center** menu allows the user to quickly center on most objects in ECU's databases. This includes centering on a specified Right Ascension/Declination, a specified Azimuth/Altitude, a constellation, a bright star, Messier object, Solar System object, a point on the local horizon, or on a text search of the databases. When an object is centered on the sky display, a cross-hair is used to mark it. Each centering menu selection is described separately below.

### 3.5.1 On RA/Dec...

The **On RA/Dec...** menu selection presents a dialog box allowing the user enter a specific Right Ascension and Declination to center the sky display on. The Right Ascension is entered as hours and minutes. The Declination is entered as

degrees and minutes.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the sky display, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

When the dialog box ends, ECU centers the sky display at the coordinates entered. This menu selection can also be activated by pressing the left mouse button while the mouse is in either of the boxes which display the current Right Ascension/Declination in the ECU status display area.

### **3.5.2 On Az/Alt...**

The **On Az/Alt...** menu selection presents a dialog box allowing the user enter a specific Azimuth and Altitude, with reference to the local horizon, to center the sky display on. Both the Azimuth and Altitude are entered as degrees and minutes.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing the sky display, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

When the dialog box ends, ECU centers the sky display at the local horizon coordinates entered. This menu selection can also be activated by pressing the left mouse button while the mouse is in either of the boxes which display the current Azimuth/Altitude in the ECU status display area.

### **3.5.3 On Constellation...**

The **On Constellation...** menu selection presents a dialog box allowing the user to select a constellation to center the sky display on. A list box is presented containing the available list of 88 constellations in alphabetical order. The user is to select the desired constellation, then exit the dialog box. ECU then centers the sky display on the selected constellation.

### **3.5.4 On Bright Star...**

The **On Bright Star...** menu selection presents a dialog box allowing the user to select a bright star to center the sky display on. A list box is presented containing the available list of bright stars in alphabetical order. The user is to select the desired bright star, then exit the dialog box. ECU then centers the sky display on the selected bright star.

### **3.5.5 On Messier Object...**

The **On Messier Object...** menu selection presents a dialog box allowing the user to select a Messier Object to center the sky display on. A list box is presented containing the available list of 110 Messier objects in numerical order. The user is to select the desired object, then exit the dialog box. ECU then centers the sky display on the selected Messier object.

### **3.5.6 On Solar System Object**

The **On Solar System Object** menu selection contains a sub-menu of all the Solar System objects (Sun, Moon, Planets, and Comets). The menu item selected is centered on the sky display.

### **3.5.7 On Point on Horizon**

The **On Point on Horizon** menu selection contains a sub-menu of all the cardinal points on the local horizon plus the Zenith (the overhead point). The menu item selected becomes centered on the sky display.

### **3.5.8 On Database Search...**

The **On Database Search...** menu selection is used to search the ECU databases for a specified object. If a match is found, the specified object is centered on the sky display. The user is presented with a dialog box which prompts for a line of

text. If the 'OK' button is pressed, the search commences. The line of text entered is immediately converted to upper case to avoid ambiguities and all spaces are removed. The object types which can be searched for are listed below:

- a) **Constellations** - the 88 constellations can be searched by entering their complete formal name (eg. 'Ursa Major').
- b) **Bright Stars** - bright stars can be searched by entering their complete formal name (eg. 'Deneb').
- c) **Stars** - any star in the Yale Bright Star (YBSC) database can be searched by entering either its Smithsonian Astrophysical Observatory (SAO) catalogue number with the prefix 'SAO', its Yale number with the prefix 'HR', or its Henry Draper (HD) catalogue number with the prefix 'HD'. For example, to find the SAO star number 49898, enter 'SAO49898'. Note that entering 'sao 49898' would be just as effective because the case of the input and spaces are ignored. This search is limited to searches of stars in the Yale Bright Star Catalogue database. SAO stars which are fainter than 6.5 magnitude (the extended stellar database) are not searched, primary due to the excessive time that it would take to search the entire SAO database of about 250,000 stars. Searching for YBSC stars is not available in the SHAREWARE VERSION of ECU.
- d) **Deep Sky Objects** - deep sky objects can be searched by entering either their primary name or 'Other Names:' as stored in the SAC deep sky database (see Section 4.). For example, the Andromeda Galaxy can be found by entering either its official name 'NGC224' or its common name (other name) 'M31'. Searching for deep sky objects is not available in the SHAREWARE VERSION of ECU.

If the search is not successful, a message box will appear informing the user of this.

### 3.6 Animation Menu

The **Animation** menu controls all of the functions of ECU's animation mode. The animation mode is used to simulate astronomical events which are affected by changes in the time. The animation mode has the following features.

- a) Time can be automatically stepped in any step from 1 minute to 4 years or any arbitrary number of minutes, hours, days, or years.
- b) Time can be stepped in either forward or reverse.
- c) The time between time steps can be set from 0 to 60 seconds.
- d) The trail history can be stored as either the objects Right Ascension/Declination or its Azimuth/Altitude.
- e) The solar system objects can be trailed with dots drawn behind them.
- f) The number of dots used in the trail can be set from 10 to 100.
- g) The sky display can be made to 'lock' on any solar system object, or point with reference to the local horizon.
- h) The time can be manually stepped, either forward or in reverse.
- i) All of the features of ECU can be used while the animation mode is running due to the multi-tasking nature of Windows, and thus of ECU.

Animation mode is best learned by experimentation, however, the menu items which control the animation mode are described in the sections below. When using the animation mode, the sky display updates may "flicker", unless the 'Sky Drawing Mode' is set to 'Fast Update' (see Section 3.3.7).

#### 3.6.1 Start

The **Start** menu selection starts the animation mode. If a 'check mark' precedes the menu selection, animation mode is running.

#### 3.6.2 Stop

The **Stop** menu selection stops the animation mode. The ESC key can also be used to stop the animation mode.

#### 3.6.3 Forward One Step

The **Forward One Step** menu selection steps the time forward by one time step. The time step is displayed to the left of the time step buttons in the status area. This menu selection can also be executed by pressing the '+' key or the '+' button.

#### 3.6.4 Reverse One Step

The **Reverse One Step** menu selection steps the time in reverse by one time step. The time step is displayed to the left of the time step buttons in the status area. This menu selection can also be executed by pressing the '-' key or the '-' button.

### 3.6.5 Trails On

The **Trails On** menu selection enables the drawing of trails (small crosses) behind the Solar System objects. If the trails are enabled, a 'check mark' will precede this menu selection.

### 3.6.6 Maximum Trails...

The **Maximum Trails...** menu selection presents a dialog box allowing the user to enter the number of trails (10 to 100) to be drawn behind Solar System Objects.

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

### 3.6.7 Animation History

The **Animation History** menu selection presents a sub-menu of the selections: **RA/Dec** and **Anim/Alt**. These selections control whether the animation history (the previous positions) is saved as the Right Ascension and Declination of the object or as its Azimuth and Altitude with reference to the local horizon. The latter setting is useful for observing an object's path relative to the local horizon. A good example of this would be to plot the positions of the planet Mercury as it passes through an eastern or western elongation and becomes visible in the evening or morning sky. Beware, however, that the actual positions shown in the object trails (except for the current position) are **not** correct with reference to the background stars for the time shown. Also, this setting operates slowly, because the computational overhead is higher. A 'check mark' will immediately precede current setting. For normal use, ensure that this setting is set to **RA/Dec**.

### 3.6.8 Lock On Current RA/Dec

The **Lock On Current RA/Dec** menu selection causes the animation mode to be locked on the current Right Ascension and Declination. In fact, it turns 'lock mode' off. If locked on the current RA/Dec, a 'check mark' will immediately precede this menu selection.

### 3.6.9 Lock On Current Azim/Alt

The **Lock On Current Azim/Alt** menu selection causes the animation mode to be locked on the current altitude and azimuth, with respect to the local horizon. This feature is very useful for 'watching' a particular horizon as the constellations rise or set, or as a planet such as Mercury crests above the horizon. If locked on the current Azim/Alt, a 'check mark' will immediately precede this menu selection.

### 3.6.10 Lock On Solar System Object

The **Lock On Solar System Object** menu selection presents a sub-menu of all the Solar System objects (Sun, Moon, Planets, and Comets). The menu item selected becomes locked to the center of the sky display in animation mode. A 'check mark' will immediately precede the Solar System object locked.

### 3.6.10 Time Direction

The **Time Direction** menu selection presents a sub-menu of the selections: **Forward** and **Reverse**. These selections control the direction in which time is stepped when the animation mode is running. A 'check mark' will immediately precede the time direction setting.

### 3.6.11 Time Step

The **Time Step** menu selection presents a sub-menu of the selections: **Enter Time Step...**, **Increase** and **Decrease**. The **Enter Time Step...** menu selection presents a dialog box allowing the user enter an arbitrary time step. The user is to enter the desired step size as a number (decimals are allowed). The unit of time (minutes, hours, days, or years) used is selected by pressing the appropriate 'radio button'. Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field. This dialog box can also be selected by clicking the mouse over the area where the time step is displayed (to the right of the time step arrows) in the status area.

The latter two selections **Increase** or **Decrease**, by one notch, the amount of the animation mode time step. The current time step is shown as the fourth sub-menu item. These two selections are duplicates of the time step arrows in the status area.

### 3.6.12 Animation Speed...

The **Animation Speed...** menu selection presents a dialog box allowing the user enter the number of seconds between animation mode updates (0 to 60 seconds).

Ending the dialog box is accomplished by pressing the 'OK' button. Aborting, without changing, is accomplished by pressing 'Cancel'. If an error is detected when ending the dialog box, a 'beep' will sound and the cursor will be placed at the offending field.

## 3.7 Help

The **Help** menu has five entries. The first selection, **About ECU...**, presents a message box identifying ECU, its version number, its copyright notice, and how to contact the author.

The second selection, **Registering ECU...**, presents a dialog box explaining how to register the SHAREWARE version of ECU. The third selection, **Benefits of Registration...**, presents a dialog box listing the benefits of registering the SHAREWARE version of ECU.

The fourth selection, **Willman-Bell Credits...**, presents a message box identifying that ECU contains source code that which is copyrighted by Jeffrey Sax. The source code referred to, provides high accuracy astronomical calculations based on the algorithms described in the book: **Astronomical Algorithms by Jean Meuss** (distributed by Willman-Bell). The message given in the message box is a requirement of distributing programs containing Jeffrey's source code.

The fifth selection, **Other Credits...**, presents a dialog box that recognizes the efforts of the Saguaro Astronomy Club, and the Yale and Smithsonian Observatory for the preparation of their deep sky and stellar databases respectively.

## 4. Databases and Calculations

This section will describe the databases built-in to ECU and the astronomical calculations used. ECU contains several databases. The databases which will be covered in this section are the stellar database and the deep sky database. Other databases include the label, constellation line, and geographic location databases.

ECU uses the algorithms described in the book: "Astronomical Algorithms" by Jean Meuss for all of the "high accuracy" solar system calculations and most other astronomical calculations as well. The "low accuracy" solar calculations are from the book: "Practical Astronomy with your Calculator" by Peter Duffett-Smith.

### 4.1 Stellar Database

The stellar database is divided into two parts. The first part, the Yale Bright Star Catalog (files YBSC1.ECU and YBSC2.ECU), is standard with the REGISTERED version of ECU. It contains 9110 stars to magnitude 6.5 with a wealth of information about each star. The other star database is the optional extended stellar database, the Smithsonian Astrophysical Observatory (SAO) Star Catalogue. The entire SAO catalog contains some 259,000 stars. The Yale stars and those with the magnitude unknown were extracted leaving a database of 245654 stars to about magnitude 9.5.

Each database contains the magnitude (visual, if available), Right Ascension, Declination in J2000.0 coordinates and are displayed on the sky display using this epoch. The Yale Catalogue provides several catalogue numbers and names for each star. These include the Bayer/Flamsteed identification, the Yale Catalogue number, the SAO Catalogue number, and the Henry Draper Catalogue number. The full spectral classification, colour as B-V, and the proper motion of each star. The SAO Catalogue provides the SAO Catalogue number and the spectral type.

The object positions in each database are stored in integer format obtaining a resolution of about 10 arc-seconds in Declination and 20 arc-seconds in Right Ascension at the celestial equator. The SHAREWARE VERSION of ECU only contains the primary data file of the Yale Catalogue which only provides the Right Ascension, Declination, and Magnitude.

## 4.2 Deep Sky Database

The deep sky database (files SAC1.ECU and SAC2.ECU) contains a complete database of 10367 deep sky objects. The members of the Saguaro Astronomy Club (SAC) (pronounced sa-war-oh) of Phoenix, Arizona have provided much of the effort to compile this database (database version 5.2). The database includes the entire NGC catalog, plus other interesting deep sky objects. Selected fields of the SAC database were extracted for use in ECU. The object positions are stored in integer format obtaining a resolution of about 10 arc-seconds in Declination and 20 arc-seconds in Right Ascension at the celestial equator. Only the object type, magnitude, and position are available with the SHAREWARE VERSION of ECU. These fields are described below:

- a) **Object Name** - usually the NGC number, but for objects with no NGC value, other catalogs are used. The abbreviations listed below are used to represent the other catalogs.

Abell	- George Abell (planetary nebulae and galaxy clusters)
AM	- Arp-Madore (globular clusters)
Antalova	- (open clusters)
Bark	- Barkhatova (open clusters)
B	- Barnard (dark nebulae)
Basel	- (open clusters)
Berk	- Berkeley (open clusters)
Be	- Bernes (dark nebulae)
Biur	- Biurakan (open clusters)
Blanco	- (open clusters)
Bochum	- (open clusters)
Ced	- Cederblad (bright nebulae)
Cr	- Collinder (open clusters)
Czernik	- (open clusters)
Do	- Dolidze (open clusters)
DoDz	- Dolidze-Dzimsejshvili (open clusters)
Dun	- Dunlop (globular clusters)
Fein	- Feinstein (open clusters)
Frolov	- (open clusters)
Gum	- (bright nebulae)
H	- William Herschel (globular clusters)
Haffner	- (open clusters)
Harvard	- (open clusters)
He	- Henize (planetary nebulae)
Hogg	- (open clusters)
HP	- Haute Provence (globular clusters)
Hu	- Humason (planetary nebulae)
IC	- 1st and 2nd Index Catalogs to the NGC (All types of objects except dark nebulae)
Isk	- Iskudarian (open clusters)
J	- Jonckheere (planetary nebulae)
K	- Kohoutek (planetary nebulae)
King	- (open clusters)
Lac	- Lacaille (globular clusters)

Loden	- (open clusters)
LDN	- Lynds (dark nebulae)
Lynga	- (open clusters)
M	- Messier (all types of objects except dark nebula)
Mrk	- Markarian (open clusters and galaxies)
Mel	- Melotte (open clusters)
M1	- Minkowski (planetary nebulae)
NGC	- New General Catalog of Nebulae & Clusters of Stars. (All types of objects except dark nebulae)
Pal	- Palomar (globular clusters)
Pismis	- (open clusters)
PK	- Perek & Kohoutek (planetary nebulae)
RCW	- Rodgers, Campbell, & Whiteoak (bright nebulae)
Roslund	- (open clusters)
Ru	- Ruprecht (open clusters)
Sa	- Sandqvist (dark nebulae)
Sher	- (open clusters)
Sh	- Sharpless (bright nebulae)
SL	- Sandqvist & Lindroos (dark nebulae)
Steph	- Stephenson (open clusters)
Stock	- (open clusters)
Ter	- Terzan (globular clusters)
Tombaugh	- (open clusters)
Ton	- Tonantzintla (globular clusters)
Tr	- Trumpler (open clusters)
UGC	- Uppsala General Catalog (galaxies)
UKS	- United Kingdom Schmidt (globular clusters)
Uppgren	- (open clusters)
vdB	- van den Bergh (open clusters, bright nebulae)
vdBH	- van den Bergh & Herbst (bright nebulae)
vdB-Ha	- van den Bergh-Hagen (open clusters)
Vy	- Vyssotsky (planetary nebulae)
Waterloo	- (open clusters)
Westr	- Westerlund (open clusters)

b) **Other Name** - contains other catalog designations that the object is known by. The same abbreviations as in a) are used.

c) **Object Type** - the type of object from the list below.

Asterism  
 Bright Nebula  
 Cluster with Nebulosity  
 Dark Nebula  
 Galaxy cluster  
 Galaxy  
 Globular Cluster  
 Diffuse Nebula in a Galaxy  
 Globular Cluster in a Galaxy  
 Cluster with Nebulosity in a Galaxy  
 Cluster with Nebulosity in the LMC  
 Diffuse Nebula in the LMC  
 Globular Cluster in the LMC  
 Open cluster in the LMC  
 Nonexistent in RNGC  
 (means Sulentic and Tifft couldn't find it on the POSS plates for inclusion in the RNGC)  
 Open Cluster



Planetary Nebula  
 Cluster with Nebulosity in the SMC  
 Diffuse Nebula in the SMC  
 Globular Cluster in the SMC  
 Open cluster in the SMC  
 Quasar  
 Unverified Southern Object  
 Multiple Star

- d) **Position** - the object's position, Right Ascension and Declination, in the J2000.0 epoch.
- e) **Magnitude** - the object's brightness to the nearest tenth. There are many objects which have no published magnitude; they are listed as ???. Dark nebulae obviously have no magnitude, so they are also listed as ???.
- f) **Description** - a visual description of the object. Most of these are from the NGC, some are from prominent amateurs. Back issues of Deep Sky Magazine, Astronomy magazine, Sky and Telescope magazine and Burnham's Celestial Handbook are used as a source of some of these descriptions. The descriptions use the abbreviations from the NGC and Burnham's. They are given below:

! remarkable object	!! very remarkable object	
am among	n north	
att attached	N nucleus	
bet between	neb nebula, nebulosity	
B bright	P w paired with	
b brighter		p pretty (before F,B,L or S)
C compressed	p preceding	
c considerably	P poor	
Cl cluster	R round	
D double	Ri rich	
def defined		r not well resolved, mottled
deg degrees	rr partially resolved	
diam diameter	rrr well resolved	
dif diffuse	S small	
E elongated	s suddenly	
e extremely	s south	
er easily resolved	sc scattered	
F faint	susp suspected	
f following	st star or stellar	
g gradually	v very	
iF irregular figure	var variable	
inv involved	nf north following	
irr irregular	np north preceding	
L large	sf south following	
l little	sp south preceding	
mag magnitude	11m 11th magnitude	
M middle	8... 8th magnitude and fainter	
m much	9...13 9th to 13th magnitude	

- g) **Size** - the size of the object in minutes of arc (') or seconds of arc (").
- h) **Class** - the class of the object. Several professional classification schemes are contained here.

### Trumpler type for open clusters

#### Concentration

- I. Detached, strong concentration toward the center
- II. Detached, weak concentration toward the center

- III. Detached, no concentration toward the center
- IV. Not well detached from surrounding star field

Range in brightness

- 1. Small
- 2. Moderate range
- 3. Large range

Richness

- p Poor (<50 stars)
- m Moderately rich (50-100 stars)
- r Rich (>100 stars)

An "n" following the Trumpler type denotes nebulosity in cluster

### Shapley-Sawyer concentration rating for globular clusters

The values range from 1 to 12, smaller numbers are more concentrated clusters.

### Vorontsov-Velyaminov type for planetary nebulae

- 1. Stellar
- 2. Smooth disk (a, brighter center; b, uniform brightness; c, traces of ring structure)
- 3. Irregular disk (a, very irregular brightness; b, traces of ring structure)
- 4. Ring structure
- 5. Irregular form similar to diffuse nebula
- 6. Anomalous form, no regular structure

Some very complex forms may combine two type  
s.

### Hubble type for galaxies

- E elliptical, E0 is roundest to E7 is flattest subgroups; 'd' is dwarf, 'c' is supergiant, 'D' has diffuse halo
- S Spiral, 'a' has tightly wound arms, 'b' has moderately wound arms and 'c' has loosely wound arms
- SB Spiral with central bar
- Ir Irregular

## 5. Identify Objects

The identify objects dialog box, obtained by "clicking" on any object on the sky display with the left mouse button, contains various information pertaining to the selected object. The information common to all object types includes the Right Ascension and Declination, the Altitude and Azimuth with reference to the local horizon, and the time the object rises and sets. Each object type is listed below with each one's specific information that is displayed in the identify objects dialog box.

- a) **Sun** - the sun's distance, in astronomical units; and its size, in minutes of arc are displayed.
- b) **Moon** - the moon's distance from the Earth, in kilometres; its size, in minutes of arc; its age, in days; and its phase are displayed.
- c) **Planets** - the planet's magnitude; its distance from the Earth, in astronomical units; its size, in seconds of arc; and its phase (0 to 1) are displayed.
- d) **Comets** - the comet's magnitude; and its distance from the Earth and the Sun in astronomical units are displayed.
- e) **Yale Bright Star Catalogue Stars** - the star's magnitude; its Bayer/Flamsteed identification; its Yale Catalogue

number; its SAO Catalogue number; its Henry Draper Catalogue number; its spectral classification; its colour as B-V; and its proper motion.

- f) **Deep Sky Objects** - the object's magnitude (if known); its primary and other names; its description; its size; and its object class are displayed. See section 4.2.

If more than one object is in the vicinity, the "Next" button can be pressed to update the dialog box with new information for the next object. The "Precess" button precesses the object's coordinates to the epoch of the current date.

A new feature available with this version of ECU is the ability to show graphics images of celestial objects on the screen from within ECU. "Show" button will show a picture of the object (if one exists) on the screen. ECU uses the shareware program WinGIF to provide this feature. WinGIF is shareware like ECU, so if you use it, please register it, too. A copy of WinGIF is provided on the Registered ECU disk and should be installed in the ECU program directory, so that ECU can find it.

At the moment, I do not include **any** images with ECU; only the facility to display them with the help of WinGIF. All images must be stored in GIF format and be in the directory "GIFS" from within your main ECU directory. The name of the GIF files must be the same as the primary object's name that appears in the Identify Objects dialog box. For example, a image of the Moon should be called "MOON.GIF" or an image of NGC7009 (the Saturn Nebula) should be called "NGC7009.GIF".

The dialog box can be terminated in four ways. If the "Quit" button is pressed, the dialog box will terminate immediately. If another object is selected, the current dialog box will be replaced with a new one. If the left mouse button is pressed while the cursor is not near an object, the dialog box will terminate. Finally, the <ESC> key can be pressed.

## 6. The Future of ECU

The future of ECU depends on you. If you register it, it gives me the signal that you are using it, which will give me lots more incentive to improve it (if no one uses it, why improve it?). Below is a partial list of the features, in no particular order, which are coming in future releases of ECU.

- improve the chart printing by including programmable fonts, non-overlapping text, customized titles, borders, etc.
- a local horizon mode that will always display the horizon parallel to the bottom of the screen (highly desired).
- separate the Messier database from the SAC database so that it is fully available in the shareware version
- add the position angle into moon phases
- draw the moon and sun on the sky exactly as it would appear, even if it look a bit odd (ie. not round)
- add a dialog box for the labels and lines settings
- add Dreyer deep sky object description help dialog box
- add an observing list printed output of objects currently on the sky display
- add Earth's shadow for simulating lunar eclipses
- add a solar system ephemeris printed output
- add more common star names and cross reference them to their Yale equivalent
- add common deep sky object names and cross reference them to the deep sky database
- add "Center on Common Deep Sky..."
- add the display of sidereal time
- improve the animation mode by allowing the date and time to be drawn next to object trails.
- Hubble Guide Star Catalog CDROM support
- Meade LX200 computerized telescope support
- add ability for the user to add objects
- add ability for the user to add customizable object labels
- add support for the SGT-MAX / MicroGuider digital setting circle device
- allow the user to add descriptions (an observing log) of objects
- add display of Jupiter's moons
- add display of Saturn's moons/rings
- enhancements to the manual, particularly by adding examples of how to simulate common astronomical events
- allow fonts to be set by the user
- allow Bayer and Flamsteed designations to be displayed on the screen and in printed charts.

- label deep sky objects
- add separate deep sky magnitude limits for each deep sky type
- add the ability to enter asteroid-type orbital elements
- add the ability to load and save comet/asteroid elements from a text file
- provide a dialog box that will give rise/set info for the Sun and Moon and the beginning/ending of twilight
- fix the problem of overlapping text labels
- and many other smaller items

**REGISTRATION FORM**  
**The Earth Centered Universe™**  
*Sky Visualization Program for Microsoft Windows™ 3.0 or 3.1*  
*SHAREWARE VERSION 1.4 (Released April 1993)*

NAME: \_\_\_\_\_

ADDRESS LINE 1: \_\_\_\_\_

ADDRESS LINE 2: \_\_\_\_\_

ADDRESS LINE 3: \_\_\_\_\_

COUNTRY: \_\_\_\_\_

TELEPHONE NUMBER (S): \_\_\_\_\_

COMPUSERVE or ELECTRONIC MAIL ADDRESS: \_\_\_\_\_

ECU Registration: \$35US (\$40CDN) ..... \_\_\_\_\_  
Optional SAO Star Catalog:  
(1.44M format only) \$20US (\$23CDN) ..... \_\_\_\_\_  
Future upgrade: \$15US (\$15CDN) ..... \_\_\_\_\_  
Total: [ ] US or [ ] CDN..... \_\_\_\_\_  
Disk size: [ ] 3.5" 1.44M or [ ] 5.25" 1.2M  
Payment Method: [ ] Postal Money Order [ ] Personal Check  
[ ] Bank Check [ ] Cash

Registration will bring, by air-mail, the most current version of ECU and a **printed manual**. You will also receive **notices** of major upgrades and be entitled to **free support**.

Americans and Canadians may make payment by **personal check**. Others may send an "International Postal Money Order" (please send registration form separately), a certified check from a bank, or by sending US Cash by "Certified Mail" (for your security). Unfortunately, at the moment, I cannot accept Credit Cards. Please note that you can also register on Compuserve (see "Registering ECU..." in ECU). Send this form with payment to:

David Lane (ECU)  
4-26 Randall Avenue  
Halifax, Nova Scotia  
Canada B3M 1E2

Please describe yourself and your computer:

Microprocessor: [ ] 486DX [ ] 486SX [ ] 386DX [ ] 386SX [ ] 286  
RAM Memory: \_\_\_\_\_ Megabytes Hard Disk Size: \_\_\_\_\_ Megabytes  
Windows Version: [ ] 3.0 [ ] 3.1 [ ] Other: \_\_\_\_\_  
Graphics Card: [ ] SuperVGA [ ] VGA [ ] EGA [ ] Other \_\_\_\_\_  
Printer: [ ] Laser [ ] Postscript [ ] 9-pin dot matrix  
[ ] 24-pin dot matrix [ ] ink jet  
[ ] plotter  
[ ] Other \_\_\_\_\_

How would you describe yourself (mark all that apply):

[ ] Casual interest in astronomy	[ ] Novice amateur
[ ] Intermediate amateur	[ ] Advanced amateur
[ ] Absolute Astro-Nut (like me!)	[ ] Armchair Astronomer
[ ] Observing Astronomer	[ ] Professional Astronomer
[ ] Educator	[ ] Other _____

Where did you hear about ECU? \_\_\_\_\_

Comments or features you would like to see: \_\_\_\_\_

\_\_\_\_\_