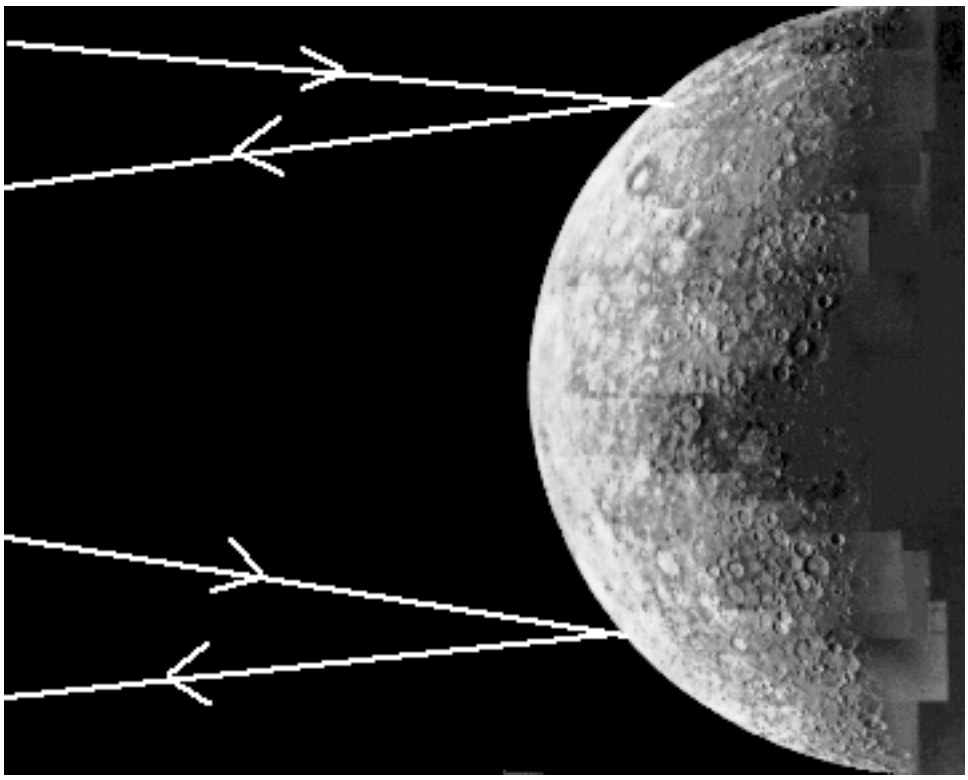
# RADAR MEASUREMENT OF THE ROTATION RATE OF MERCURY

SOFTWARE USER'S GUIDE

A Manual to Accompany Software for
Introductory Astronomy Lab Exercise
Document SUG 4: Version 1.0



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# TABLE OF CONTENTS


**I. INTRODUCTION** ..... 1
- I-1. Purpose ..... 1
- I-2. Acknowledgements ..... 1

**II. SYSTEM REQUIREMENTS** ..... 1
- II-1. Hardware ..... 1
- II-2. Operating System ..... 1
- II-3. Disk Space ..... 1
- II-4. Video Issues ..... 2
  - II-4.1. Color ..... 2
  - II-4.2. Resolution/Size ..... 2
  - II-4.3. Changing the Video Driver ..... 2

**III. INSTALLATION AND OPERATION** ..... 3
- III-1. Unpacking the Files ..... 3
- III-2. Running the Exercise ..... 5
  - III-2.1. File Manager ..... 5
  - III-2.2. Installation Under Windows ..... 5

**IV. FILES INCLUDED WITH EXERCISE** ..... 6

**V. USER OPTIONS** ..... 7
- V-1. The Options Dialog ..... 7
  - V-1.1. Access and Password ..... 8
  - V-1.2. The Save Options File (MERCOPTS.INI) ..... 8
  - V-1.3. File Path and File Names ..... 9
  - V-1.4. Parameters and Selectable Options ..... 9
- V-2. Bitmap (.BMP) Files ..... 10
- V-3. Help (.HLP) Files ..... 11
- V-4. Data (.DAT) Files ..... 11
  - V-4.1. Pulse Profile Files ..... 11
- V-5. Logout “Reminder” File ..... 12

**VI. ASTRONOMICAL DATA, MODELS AND ALGORITHMS** ..... 12

**REFERENCES** ..... 13

# I. INTRODUCTION

## I-1. Purpose

This document provides information for users of the CLEA softwaremodule "The Rotation of Mercury". It includes discussions of hardware and operating system requirements (Section II); software installation and operation (Section III); files associated with the exercise (Section IV); user options and file formats for possible user modifications (Section V); and astronomical data, models and algorithms employed in the exercise (Section VI). The material in this guide is intended for use by the instructor and by other personnel involved in installing and configuring the exercise software and PC hardware. It is not intended for distribution to the students. (The word "user" as it appears in herein should be interpreted as "instructor", and not "student".)

## I-2. Acknowledgements

Development of CLEA exercises and materials, including this guide, is supported in part by National Science Foundation Grant USE 9155927 and by Gettysburg College.

# II. SYSTEM REQUIREMENTS

## II-1. Hardware

This exercise should run successfully on any IBM or compatible PC capable of running Microsoft Windows 3.0 or 3.1. This includes processors Intel 80286 (or equivalent) and above (80386, 80486, Pentium) with a minimum of 2 MBytes of RAM. For optimum performance we recommend a fairly fast processor capable of running Windows 386 Extended mode (25 MHz 386SX or above), with 4 MBytes or more of RAM. A floating point coprocessor (Intel 80x87 or equivalent) is highly recommended but is not required. (A Weitek coprocessor should cause no problems if present, but is not used.) A mouse is a definite requirement (but you need not load a separate mouse driver if you use a mouse with Windows). A color display (VGA or better) is required; a high-speed high-resolution video card/driver is advantageous (see Section II-4).

## II-2. Operating System

This software runs under Microsoft Windows Versions 3.0 and 3.1 (and compatible modes on later versions and/or equivalents). You cannot run it standalone under DOS.

## II-3. Disk Space

A hard disk is required. This exercise uses approximately 1.2 MByte of disk space. You can reduce this somewhat by deleting unneeded bitmap files (see Section V-2).

## II-4. Video Issues

Unfortunately, beyond VGA (640x480, 16 colors) and SuperVGA (800x600, 16 colors), there is very little standardization in video cards/drivers used to run Windows. Most newer cards offer additional modes - resolutions to 1024x768 and beyond, and 256 and more (16K!) colors - and many Windows users are probably unaware of how their system is configured and what mode they are using. We have attempted to address the lowest common denominator (VGA - 640x480 pixels, 16 colors) in our development of these programs, but many of the available image files do not display well in 16 colors and so we have adopted 256 colors as our standard. Individual discussions of color, resolution, and changing video drivers are presented in Sections II-4.1 through II-4.3.

### II-4.1. Color

As noted, best results will be obtained with this exercise when Windows is configured with a graphics driver that uses 256 colors. (These exercises are not designed for monochrome monitors, and are not generally usable in monochrome.)

If you are running Windows with a 16-color video card and/or driver, the software will detect this and access special 16-color bitmaps where required. These are satisfactory, but not as eye-catching as the 256-color versions. (In this exercise, only the logo and title screens have a noticeably different appearance on a 16-color display.) If your video card supports 256 colors, you may be able to change the Windows driver to one that makes use of the full color range (see Section II-4.3). The exercise software will then automatically use the 256-color versions of the bitmaps.

### II-4.2. Resolution/Size

This exercise is designed to display full-screen in a 640x480 pixel graphics mode. Higher resolution modes (800x600, 1024x768) may also be used - the display will appear smaller, but properly proportioned. This can be advantageous, as Help (and sometimes Result) windows can be brought up, resized if necessary, and re-positioned on the screen so that they can be referred to directly as the exercise proceeds. (The process for changing the resolution is the same as that for changing the color mode, you must change the video driver, following the steps outlined in Section II-4.3.) One minor complication is that the fonts do not scale exactly between all graphics modes. This sometimes results in oversized labels on the control buttons, and truncated text lines with a horizontal scroll bar on the Help windows. If this occurs on your Help window, simply drag the right side of the Help window outward until the horizontal scroll bar disappears, and the text lines will be visible in their entirety.

### II-4.3. Changing the Video Driver

If your computer is currently running Windows in a 16-color mode and you would like to improve the appearance of the displays, and/or you would like to try a different screen resolution, you may be able to change the Windows video driver (if your video card will support the mode you want).

Begin by consulting your Windows documentation and installation procedure for information on installing/checking/changing the graphics driver. Also check the documentation and any software that came with your video card. A Windows driver (or drivers) may have been included, and the documentation may describe the installation procedure. The following is a general outline of the basic steps required to change the video driver in Windows 3.1. The procedure for Windows 3.0 is similar, but some differences may be encountered.

1) Have the following on hand: Your Windows installation disks and any disks containing drivers and other software that came with your video card.

2) Start Windows. From the "Main" window select "Windows Setup".

3) Select "Options", then select "Change System Settings".

4) Select "Display". A list of drivers will appear, with your current driver highlighted. You should make a note of it so you can return to it later. If a driver appropriate to your video card and desired mode appears on the list, select it. If you are installing a driver that came with your card and it does not appear on the list, select "Other".

5) Follow the directions that appear.

You may want to perform the process several times to sample various modes. Once specific drivers have been loaded you can switch between them fairly rapidly using the above procedure - you do not need the Windows and drivers disks.

One note of caution: This procedure is not without its hazards. For example, if you select and install a driver/mode that is not supported by your video card you may render Windows unusable. In this case you will need to run SETUP from DOS to restore your original driver. If you start Windows from your AUTOEXEC.BAT file you will probably have to boot DOS from drive A: to begin this process. Then change to the directory C:\WINDOWS and type SETUP at the prompt.

## III. INSTALLATION AND OPERATION

### III-1. Unpacking the Files

All files for this exercise are compacted into the distribution file CLEA_MER.ZIP. They must be extracted using the PKUNZIP program (also included on the distribution diskette), and placed together in a single directory, such as C:\MER_LAB. This exercise may be placed in the same directory as other CLEA exercises, as the names of exercise-specific files are unique to each. This will result in a small savings in disk space, since duplicate copies of the files CLEALOGO.BMP, CLEALG16.BMP and CLEAHELP.HLP will not be needed. We recommend, however, that you place each exercise in its own directory, as there is then no confusion as to which files are involved when you wish to update or copy specific exercises.

(It is possible to separate the executable code for the exercise from its image and data files. This allows, for example, multiple set-ups or variations of the same exercise. See the discussion of the Path parameter in Section V-1.3.)

The unpacking process is probably best accomplished under DOS, as follows:

1) Access the DOS prompt. If you are running under Windows you can either exit (select "File", "Exit Windows" on the Program Manager menu), or select the MS-DOS Prompt icon from the Main (probably) program group.

2) If you are not placing the exercise in an existing directory, create a new directory. For example:

   **C:>MD C:\MER_LAB<Enter>**

3) Go to the directory where you are placing the exercise. For example:

   **C:>CD C:\MER_LAB<Enter>**

4) Place the CLEA distribution diskette in the proper disk drive for a high-density (1.44 MB) 3 1/2 inch diskette (probably A: or B:)

5) Assuming you have placed the disk in drive B:, enter the following (for drive A:, substitute "A:" for "B:"):

   **C:>B:PKUNZIP B:CLEA_MER<Enter>**

   If you are replacing an earlier version in the same directory, enter instead:

   **C:>B:PKUNZIP -O B:CLEA_MER<Enter>**

   In this case (replacement), you should also check the README file that came with the updated software. There may be special instructions, such as additional files to delete. In general, any existing files in the directory with extension .INI should be deleted. (If you have changed any options from their default values you will have to reset them when you run the new software - see Section V-1.)

6) If you are placing the lab in the same directory as other CLEA labs, you may get messages such as:

   PKUNZIP:Warning! file: CLEALOGO.BMP already exists. Overwrite (y/n)?

In general, you should respond "y" (Yes) to these messages, but again, check the README file.

**NOTE:** We highly recommend that you follow the above procedure (unpack the .ZIP file) whenever you load this software on another machine. (Do not copy the unpacked files from one machine to another.) This is particularly true if you have made any configuration changes (Section V), and especially if you have deleted any files. Our software has some internal ability to adapt to its surroundings, but it must all be present in its original form to accomplish this. For this reason we ask that if you distribute this software to others, you distribute only the original .ZIP version.

### III-2. Running the Exercise

As noted in Section II-2, this exercise must be run under Microsoft Windows, Versions 3.1 or 3.0. Once you have installed the software and have started (or returned to) Windows you may run the exercise from the Windows File Manager, or install it under Windows and run it from an icon.

### III-2.1. File Manager

As a quick method of running the exercise, access the FilE Manager by double clicking on its icon (probably in the Main Program group window). Access the directory where the you have loaded the files, and double click on the entry for CLEA_MER.EXE. Alternatively, select "File", "Run" from either the File Manager or Program Manager menu and enter the appropriate command line, for example:

**C:\MER_LAB\CLEA_MER.EXE.**

### III-2.2. Installation Under Windows

As part of a permanent installation, and certainly for student use, the exercise should be installed under Windows. The procedure for this is as follows (assuming the software has been unzipped into directory C:\MER_LAB):

1) If you have already created a program group to hold CLEA exercises, select it from the Program Manager window and go to step 4. If not, proceed with step 2.

2) From the Program Manager menu, select "File", "New", "Program Group". Click on "OK".

3) Enter "CLEA" or other descriptive title in the Description field. The Group File field may be left blank. Click on "OK".

4) From the Program Manager menu, select "File", "New", "Program Item". Click on "OK".

5) Enter the following in the identified fields:

| | |
|---|---|
| Description: | "Rotation of Mercury" |
| Command Line: | "C:\MER_LAB\CLEA_MER.EXE" |
| Working Directory: | "C:\MER_LAB" |
| Shortcut Key: | (None) |
| Run Minimized: | (No) |

6) Click on "OK".

The exercise may now be run by selecting the "CLEA" program group from the Program Manager window and double clicking on the CLEA icon labeled "Mercury Rotation".

## IV. FILES INCLUDED WITH EXERCISE

The software module for each CLEA exercise includes a (largely) unique set of files that are vital to its operation. In addition to the executable code for the program (.EXE), these files hold the bitmaps for the screen displays (.BMP), data and parameters for the astronomical objects in the exercise (.DAT), text for the Help screens (.HLP), startup parameters (.INI), and documentation (.MER). Many of these files can be modified or replaced to tailor the exercise to specific classroom requirements (see Section V). The following files comprise this exercise, and should be present in your working directory after unpacking the distribution (.ZIP) file (Section III-1):

**README.MER** - Notes on the current version, including any incompatibilities with previous versions, old files that should be deleted, etc.

**UPDATE.MER** - A list of updates (by version) since version 0.50.

**USRGUIDE.MER** - This document, in text form.

**CLEA_MER.EXE** - The executable code for the exercise.

**CLEALOGO.BMP** - 256-color bitmap data for the CLEA Logo screen.

**CLEALG16.BMP** - 16-color bitmap data for the CLEA Logo screen.

**MERCLAB.BMP** - 256-color bitmap data for the Title screen.

**MERCL16.BMP** - A 16-color version of the Title screen.

**IPULSE.DAT** - Data for displaying the initial pulse.

**PULSE_0.DAT** - Base data for return pulse at T=0.

**PULSE_1.DAT** - Base data for return pulse at T=120 microseconds.

**PULSE_2.DAT** - Base data for return pulse at T=210 microseconds.

**PULSE_3.DAT** - Base data for return pulse at T=300 microseconds.

**PULSE_4.DAT** - Base data for return pulse at T=390 microseconds.

**CLEAHELP.HLP** - Text for "Help"..."On Help".

**MERCSTRT.HLP** - Text for "Help"..."Getting Started".

**MERCDATA.HLP** - Text for "Help"..."Taking Data".

**MERCWS.HLP** - Text for "Help"..."Work Sheet".

**REMINDER.MER** - Text to display when "Quit" selected (see Section V-5).

**(MERCOPTS.INI)** - NOTE: This file is not included in the distribution, but is created the first time the exercise is run. It contains default settings for options (see Section V-1.2). This file can be deleted if desired, it will then be re-created.

## V. USER OPTIONS

CLEA exercises are ready to run "as is", in essentially the form that we have used with students in our introductory Astronomy classes. However, in order to make the exercises as flexible as possible, we have included a number of options that allow the user to tailor the exercise to specific course requirements and level of difficulty. In this exercise, the instructor can vary the rate of the "real time" clock, alter or replace the base pulse profiles, and adjust the level of noise included in the displayed pulses. This adaptability is provided through two mechanisms: an options dialog that enables the user to select built-in options and change file names and path; and the files themselves, which in many cases can be modified or replaced. The options dialog for this exercise is presented in Section V-1, while modifications to the various file types are discussed in Sections V-2 through V-5.

### V-1. The Options Dialog

CLEA exercises feature an options dialog that allows the user to select built-in options, change file names, and provide a path for the bitmap and data files. A password is required for entry into this dialog to prevent access by the students.

### V-1.1. Access and Password

Access to the options dialog is provided through the Log In ("Student Accounting") screen. Select "Log In" from the main menu, and type "Instructor" (no quotes, not case sensitive) in the field labeled "Student #1". No other entry on the form is required. After entering the above, select "Ok" and then "Yes" to "Have You Finished Logging In?". A small dialog box will appear, asking for the password. Enter the password (see next paragraph), and select "Ok". If you have entered the correct password, the dialog labeled "Startup Parameters/Options" will then appear. The tab key (and shift-tab) may be used to move from field to field, or you can select fields directly with the mouse. When you are finished select "Ok" or "Cancel". If you select "Ok" the message "Save New Values in MERCOPTS.INI?" will appear. If you select "Yes", the options as they appear on the dialog screen will be saved and used as defaults the next time the exercise runs. If you select "No", the options you have set/selected will be used only for the current execution. Once you have made your selection the exercise will begin. NOTE: Once you have passed the Log In screen you cannot access the options dialog. To do so you must quit and rerun the exercise.

The default options password is "CLEA" (in caps, no quotes). The default is in effect until it is changed, and at any time that the software cannot locate the MERCOPTS.INI file in the working directory. You may change the password from the options dialog (16 characters or less, case sensitive). If you do, a small dialog box will appear asking you to repeat the new password for verification. (Note that the password is never echoed, either when it is used or when it is changed.) If the password change is verified you must also respond "Yes" to "Save New Values in MERCOPTS.INI?" to have the change take effect. The password is stored in a masked form in MERCOPTS.INI. If you forget the password, delete (or rename) MERCOPTS.INI and the password will again be "CLEA". (In this case all options will return to their original (internal) default values.)

### V-1.2. The Save Options File (MERCOPTS.INI)

The options settings for this exercise are stored in the file MERCOPTS.INI. This file is created and placed in the working directory the first time this exercise is run, regardless of whether or not the options have been modified. (If they have not, the file will contain the internal defaults.) If you access the options dialog, select "Ok", and respond "Yes" to "Save New Values in MERCOPTS.INI?", a new copy of MERCOPTS.INI will be created and the old version will be renamed MERCOPTS.BAK. If there is an existing MERCOPTS.BAK, it will be lost.

MERCOPTS.INI is stored in binary (not text) format. Changes should be made only via the options dialog (not with a text editor). If you are setting up the exercise on a number of computers in a laboratory, you can set up one via the options dialog, copy the resulting MERCOPTS.INI onto a floppy disk, and then load it into the appropriate directory on each machine.

Do not use a copy of MERCOPTS.INI with a different version of the exercise software than the one which created it. (In most cases this will be caught by the software and you will be given the option of deleting MERCOPTS.INI or quitting the program.)

If you are updating an exercise "in place" (on top of an earlier version in the same directory), you should delete any MERCOPTS.INI and MERCOPTS.BAK files in the directory before running the new version. Remember that you may need either to reset some options or copy in a correct version of MERCOPTS.INI after you do this.

### V-1.3. File Path and File Names

File names and a directory path may be entered in the identified fields on the options dialog. File names should follow the normal DOS format - a maximum of eight alphanumeric characters (first character must be alphabetic), optionally followed by a period and up to three characters as a qualifier. Bitmap files are given the qualifier .BMP, help files carry the .HLP qualifier, while data files and file lists are identified by .DAT. Note that there are usually 256-color and 16-color versions of each bitmap file (see Section II-4 for discussion). Details of each type of file are given in Sections V-2 through V-5.

The Directory Path field is provided so that a particular exercise can be used with an alternate set of files. Under normal circumstances this field should be left blank, and all the files related to the exercise should be placed in the directory identified as the Working Directory when the exercise is installed under Windows (Section III-2.2). If a path (following DOS conventions) is entered in this field, it should point to a directory that contains a complete set of bitmap, data, and help files for the exercise, with all files correctly named in the appropriate options dialog fields.

### V-1.4. Parameters and Selectable Options

The following parameters are set via the options dialog:

**Lab Table #:** The value placed in this field (up to 4 charcters - do not have to be numeric) appears as a default on the student's each PC in the lab.

**UT-Local Time (Hrs):** The value (in integer hours) of Universal Time minus local (zone) time for the presumed location of the "observatory" for this exercise. This number is used to convert the time obtained from the system clock on the individual PC to Universal Time. The table gives the standard time values for North American time zones. (For daylight time, subtract one from the table value.) The default is 5 hours (Eastern Standard Time).

| Zone | UT-ST (Hrs) |
|---|---|
| Atlantic | 4 |
| Eastern | 5 |
| Central | 6 |
| Mountain | 7 |
| Pacific | 8 |
| Alaska | 9 |
| Hawaii | 10 |

**Pulse Timer Factor "Speed up" factor for pulse travel time:** Setting this parameter to a number greater than 1.0 reduces the actual time the students must wait for the pulse to travel to Mercury and return. There is an effective upper limit to this parameter set by the overhead involved in the Windows timing apparatus and the delay involved in updating the value on the screen. This upper limit will vary on different hardware/software configurations, but is almost certainly less than 50.0. Because of the overhead factors, the default for this parameter is 1.1, to approximate real time.

**Noise Base (pixels):** The maximum amplitude of the random noise that is applied to the T=0 return pulse when it is displayed. Setting this parameter to 0 will cause the pulse profiles to be displayed from the data in the files PULSE_0.DAT...PULSE_4.DAT, without added noise. The default value is 10 pixels.

**Noise Factor:** The factor by which the noise amplitude is multiplied for each succeeding pulse. The noise increases with time following the T=0 pulse.) The default value of the noise factor is 2.0.

**Options Password:** This is the password for access to the options dialog (see Section V-1.1). Allowable passwords have a maximum length of 16 characters, and are case sensitive. The default password is "CLEA".

### V-2. Bitmap (.BMP) Files

Files that contain graphics images for display by this software must be in Windows bitmap (.BMP) format. Many available software packages that edit or create graphics images offer .BMP file output as an option, and many will convert other formats (.GIF, .PCX, etc.) to .BMP. (You will find that .BMP files are usually larger than other formats, often much larger. Windows has apparently taken the route of trading memory/disk space for display speed.)

Due to the color issues discussed in Section II-4, we provide 256-color and 16-color versions of almost all bitmaps. Again, many available graphics editing programs will reduce the number of colors to the standard 16 of VGA, and often offer a number of different techniques to accomplish this. We have found that methods which blend or "dither" the colors usually produce more satisfactory results than methods which simply map to the nearest color.

Users who wish to do so may provide their own logo (and/or title) screen(s) to replace the one(s) furnished. You will need to develop a 652x436 pixel image in .BMP format. Depending on the type of equipment you are using, you will need to create 256-color and/or 16-color versions. You can then enter the file names in the appropriate fields on the options dialog, or you can give your files the same names as the old ones and replace them in the working directory.

If you will always run in the same color mode (256-color or 16-color), you can free some disk space by deleting the unused .BMP files. Use the list in Section IV to determine which .BMP files are for the mode you are not using, and can therefore be deleted. (The 16-color .BMP files usually have "16" somewhere in their name.) If you choose to delete files, be aware that you will need these files if for any reason you change the color mode, or copy the software to a machine that runs in a different color mode (also see NOTE, Section III-1).

### V-3. Help (.HLP) Files

Help files (qualifier .HLP) for the CLEA Windows exercises are simply text files, which can be created and modified with a text editor, including the MS-DOS editor provided with Versions 5.0 and above (access MS-DOS and type "EDIT"). Text files can also be created with a word processor. (If you use a word processor, be sure that you generate your final output in straight ASCII text, not in the word processor's internal format or formatted for a printer. Most word processors have an option to generate ASCII text. You may also need to eliminate page breaks. It may be cumbersome or difficult to edit existing text files with some word processors.)

We have provided the "User Help" menu item to accommodate specific instructions, information, etc. that the instructor may wish to impart to the students. To create a user help file, simply create a text file (we recommend a maximum of 72 characters per line), copy it to the working directory, and enter its name in the User Help File field on the options dialog. You can also use a text editor to modify the existing help screens or create replacements.

### V-4. Data (.DAT) Files

This exercise uses a series of files, typically identified by the qualifier .DAT, to contain the data used to plot the pulse profile at each time step (after adding random noise). These files, like the .HLP files (Section V-3), are in text format, and can be created and maintained with a text editor. (See remarks in Section V-3 concerning the use of word processors.) In this test version, the format and other requirements for these files is rather rigidly fixed. We plan to include more flexibility in future releases.

### V-4.1. Pulse Profile Files

The pulse profile files (IPULSE.DAT, PULSE_0.DAT...PULSE_4.DAT) contain 117 entries (lines), spanning the (delta) wavelength range of -3.0 Hertz to +3.0 Hertz in equal steps. (Entry 59 is the value at 0 Hertz.) The entries, in decimal format, give the intensity at that wavelength. 75.0 is currently the largest intensity value that can be plotted.

Each file represents the time T (from first instant of reception) as follows:

**IPLUSE.DAT:** Initial (sent) pulse
**PULSE_0.DAT: T** = 0 (instant of reception)
**PULSE_1.DAT: T** = 120 microseconds
**PULSE_2.DAT: T** = 210 microseconds
**PULSE_3.DAT: T** = 300 microseconds
**PULSE_4.DAT: T** = 390 microseconds

These (seemingly arbitrary) times correspond to the pulse data from Hoff and Schmidt (1979) (see Section VI).

### V-5. Logout "Reminder" File

This (optional) file provides a mechanism for the instructor to supply customized messages to the students when they have finished the exercise. The contents of the (text) file identified in the "Reminder File" field on the options dialog are displayed whenever "Quit" is selected from the main menu. This display always concludes with the line "Select "OK" to Quit Exercise, "Cancel" to Continue", and provides pushbuttons affording the appropriate choices. A reminder file can be any text file (create with a text editor), with the following restrictions:

(1) The total message may not exceed 1023 characters.

(2) A "line" (see next) may not exceed 255 characters.

(3) Carriage return-line feed (CRLF) characters in the file will result in new lines in the output. However, additional new lines may appear because the output will wrap itself automatically. This wrapping depends on the video mode, and employs variable length characters, so the resulting line length is nearly impossible to predict. It is recommended that CRLF be used only to terminate paragraphs, which then become long lines (subject to the length restriction above). Some experimentation may be required to achieve a message that displays as intended.

We have provided a default reminder file "REMINDER.MER", which may be used as is, modified with a text editor, replaced, or simply deleted, if desired. If no reminder file is provided to the program, a short message ("Do You Really Want to Quit This Exercise?") is displayed when "Quit" is selected.

## VI. ASTRONOMICAL DATA, MODELS AND ALGORITHMS

The pulse data (files PULSE_0.DAT...PULSE_4.DAT) was taken from diagrams in Hoff and Schmidt (1979) (available as Sky and Telescope Laboratory Exercise LE11).

Computational models for the heliocentric positions of Mercury, Venus, and the Earth, used to calculate the geocentric positions of Mercury and Venus, are adapted from Meeus (1991). Periodic terms having an amplitude less than 0.5 arc minute are omitted.

The Earth-Mercury relative line-of-sight velocity is computed using the mean orbital velocities for Mercury and the Earth (47.89 km/sec and 29.79 km/sec, respectively), and assumes circular orbits. The velocities are therefore not suitable for exercises such as determining the eccentricity of Mercury's orbit form velocity variations.

## REFERENCES

Hoff, D.B. and Schmidt, G.: "Laboratory Exercises in Astronomy -The Rotation of Mercury", Sky and Telescope , 219 (1979)

Meeus, J.: *Astronomical Algorithms.* Richmond: Willmann-Bell 1991