

# Angell Hall Observatory

April 2009

## Some Basic Rules

1. There must be at least one qualified operator present at all times while the telescope is in use.
2. Two people should be present at all times for safety reasons.
3. In the event of a personal emergency, **dial 911 immediately** and worry about the telescope latter. Please use the emergency contacts listed on the phone list in the control room to let others know about the emergency.
4. No smoking anywhere within a university building, including the roof
5. No food or drink in the dome. Please use caution in the control room.
6. Access for the public or for classes is through the roof door. Do not bring groups into the control room or up the spiral stair.
7. Keep the control room door closed to prevent anyone from wandering in while you're in the dome. Keep the spiral stair door closed to prevent drafts.
8. Do not leave the dome open or the telescope running and unattended (except to go open the doors for your class). Do not open or close the dome with the telescope uncovered.
9. Check the white board for telescope status before starting up the 'scope.
10. Always check the date and time before running the tcs program.
11. Make sure the telescope is stowed properly before leaving. Check the troubleshooting section and use the website, astro-labs email or phone list to report any problems.
12. SCHEDULING: Classes/GSIs have priority from 6 – 11 PM Monday – Thursday. The student astronomical society has priority on Friday 6 - midnight. Otherwise, the observatory is first-come first-served. Please schedule all groups through the outreach program.
13. NEVER point the telescope at the Sun since serious damage WILL result. If using the 'scope during daylight hours, keep the shadow of the dome on the 'scope to prevent accidentally allowing too much light into the optics.

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# Starting Up

## ***Control Room***

1. Check the white board for any notes on telescope status.
2. Log in to the Windows PC.
3. Get the current UT from the wall clock or the Windows PC. Make sure you know if it should be AM or PM (UT is AHEAD of us). The USNO clock is bookmarked in Firefox on the windows PC.
4. Turn on the power strip on top of the blue electronics box. The telescope control system (tcs) computer next to the box will boot.
5. Once you have a prompt type *DATE*. Note this computer is set to UT, which is EST+5 hours or EDT + 4 hours and the date changes at 0h UT! If it is inaccurate, type the correct date and press enter, otherwise just hit enter.
  - a. Check the time by typing *TIME* to check the time. If the time is inaccurate, enter a time 5 – 10 seconds ahead of the current time, then press enter when the UT clock actually reaches that time. Be sure to either use military/24 time or include “a” or “p” to indicate AM or PM (but not both)
6. Type *tcs* to start the telescope control system.
7. On front of blue box, throw the following switches:
  - a. MTR DRIVER CHASSIS up.
  - b. Red HALT MOTORS out (press in to unlatch this).
  - c. DRIVES up.
  - d. TRACK up
  - e. TRACK/AUX TRACK to TRACK (up – it should already be in this position)All other switches should be down (there are white dots on the top row of switches to indicate the operating position)
8. On the windows PC, open TheSky.
9. In the “Telescope” menu, click on “Link > Establish”. A white cross hair cursor should appear at the center of the screen to indicate where the telescope is pointing. If not, see the trouble shooting section.
10. Head upstairs.

## ***Dome Opening***

1. Check the weather and the roof for obstructions, including possible snow and ice on the dome in cold months. Do not open the dome if there is anything that could possibly fall on the telescope, or if it is very humid.
2. Turn on the power strip on the desk to turn on the desk lamps.
3. Open the vents and turn on the ventilation fan (the control is located on the south wall, behind the “Hot 240” sign). Note you can do this early in the day to get the ‘scope cooled off for better seeing.
4. Make sure the cover is still on the telescope and finder scope.
5. Remove the cord from the shelf with the dome shutter controls and plug it into the outlet below the shelf.
6. Push the **upper shutter** switch to open the upper shutter. It will stop automatically when fully open.
7. Once the upper shutter is about 1 m open, push the **drop out shutter** switch left to turn on the hydraulics. Pull down on the handle on the far left side of the shelf to open the drop out shutter.
8. The hydraulics will squeal when the drop out shutter is all the way open. Release the handle and turn off the switch.
9. Once the upper shutter has stopped, turn off the switch and unplug the shutter controls. Be sure the cord is securely placed on the shelf so it cannot fall down while the dome is rotating.
10. Grab the cord sitting on the vent under the north side of the dome and plug it in.

## ***Aligning the Telescope***

1. Turn on the power strip on the desk if it isn't already on. This should turn on the tcs monitor and the red desk lamp.
2. Remove the finder cap and telescope cover. You will need to use the handpaddle and slew the telescope in order to reach the cover from the stepladder (see Moving the Telescope under Handpaddle Operations on page 10.) Do not slew due north since there is no software limit under the pole
3. On the tcs, select item 2 "movement menu"
4. Check the sidereal time "S. T. *hh mm ss*" on the tcs display.
5. Select item 3 "Select Library Object" (see also Using library objects: on page 16.
6. Enter a number between 401 and 424 equal to 401 + hours of sidereal time. E.g. if the sidereal time is 21h 57m, round the ST to 22h so 401 +ST = 423 (for more about this, see "Using Libray Objects" under "Controlling the Telescope without TheSky").
7. Answer "No" to "Any Changes". The coordinates will appear as the "Next Object" and "Slew enabled" will blink at the bottom of the screen.
8. Select item 7 "Start slew" to slew the telescope to the object.
9. Center the star first in the finder scope then in the main telescope using the handpaddle . If no star is visible, check the sky (make sure it is clear and dark enough), and see There is nothing visible in the telescope in the troubleshooting section on page 22.
10. Hit <ESC> on the tcs to go back to the main menu.
11. Select item 1 "Initialization Menu"
12. Select item 2 "Set telescope position"
13. Enter "0" for all values. Answer "No" to "Any Changes"
14. Hit <ESC> on the tcs to go back to the main menu, then select 2 for "Movement Menu".
15. The telescope is now ready for observing. You may need to repeat this process if the telescope tracking gets off for any reason.
16. Turn off the ventilation fan (it vibrates the 'scope.)

## Shutting Down

### *Stowing the telescope*

1. Put the cover on the telescope and finderscope. You may need to use the handpaddle to slew the telescope to a position where you can reach the front end of the telescope from the step stool. Do not lean or pull on the telescope tube while putting the cover on.
2. In TheSky, go to the “telescope” menu and select “Link > Terminate”.
3. Exit TheSky without saving. You can log out of the PC now, or leave it running.
4. On the tcs, select menu item 5 “set zenith position”. It will warn you this sets all track rates to zero and ask “Any changes?”. Tell it “NO”, then select 7 “start slew” to move it to the zenith position.
5. Check the levels to make sure the telescope is really level. If necessary, use the handpaddle to make adjustments.
6. Close the dome (see below).
7. Close all vents and the outside roof doors.
8. Turn off the power strip, and dome lights and head downstairs.

### *Closing the Dome*

1. All optics must be covered before proceeding.
2. Rotate the dome to its home position, which is on the white board. (See Dome Rotation under Handpaddle Operations on page 11)
3. Unplug the dome rotation power cord and place it on top of the vent.
4. Take the cord down from the shelf and plug it in.
5. Move the **upper shutter** switch to the right to start the upper shutter closing.
6. Move the **drop out shutter** switch left and push the lever up to raise the drop out shutter. Note the drop out shutter will not close if the upper shutter is too low. If you cannot get the drop out shutter to close, try opening the upper shutter.
7. Release the lever when the hydraulics squeal, indicating it is closed. If it doesn't squeal, it isn't closed.
8. Turn off the **drop out shutter** switch.
9. The upper shutter will stop when it is closed. Turn off the **upper shutter** switch.
10. Unplug the shutter control cord and place it securely on the shelf. Do not leave the dome plugged in when not in use.
11. If you didn't already, close the vents and doors, turn off the power strip and lights.

## **Control Room**

1. On the front of the blue electronics box throw the following switches:
  - a. TRACK off (down)
  - b. DRIVES off (down)
  - c. Red HALT MOTORS in all the way.
  - d. MOTOR DRIVER CHASSIS off (down.) – the halt motors and horizon limits lights will go off.
2. Turn off the power strip (there is no graceful way to exit the tcs program, so you do not need to do anything to the tcs computer before this.)
3. Exit TheSky and LOG OFF the PC if you did not do so upstairs.
4. Make sure all the lights are off (check the spiral stair light!)

## **Restarting**

If the telescope is moved, the tcs crashes, or the hardware limits are hit, you will need to restart the telescope.

1. Terminate the link with TheSky (see step 2 of Stowing the telescope, above)
2. If you can't move the telescope, skip to the next step. If the telescope can still be moved:
  - a. Select Movement menu item 5 "Set zenith position" to get the telescope close to upright
  - b. Use the Handpaddle and the spirit levels to get the telescope aligned on zenith.
3. In the control room, throw the switches as in step 1 in the Control Room, immediately above.
4. Lift the flap on the blue box to get access to the computer, and press the Reset button to reboot the tcs computer.
5. Follow steps 5 - 6 under Starting Up - Control Room. When you get to step 7:
  - a. If you could not get the telescope to zenith in step 2, DO NOT turn the TRACK switch to on. Go to step 6 below.
  - b. If you did get the telescope to zenith, finish the steps under Starting Up - Control Room and then go on to Aligning the Telescope to finish setting up the 'scope.
6. If you skipped the alignment in step 2 because telescope could not move, go back to step 2b above. DO NOT use "Set Zenith position", because the computer now thinks the tipped over position is the zenith. Follow the rest of the instructions to restart the telescope again, once it is upright.

# Using TheSky

## **Linking**

1. Establish a link by going to the Telescope menu and selecting “Link > Establish
2. To disconnect, choose “Link > Terminate”
3. “Link > Suspend” hides the crosshairs, but otherwise you are still linked to the telescope.
4. Do NOT change any of the telescope settings.

## **Appearance**

1. The white cross hair indicates the current position of the telescope
2. The red target indicates the current selection
3. The mouse appears as an arrow pointer
4. The area visible to the telescope is displayed on the screen. If you zoom in or out, this area will no longer reflect what is visible to the telescope.

## **Controlling the Telescope With TheSky**

1. Click an object to select it. The red target should appear around it and an information window should pop up.
2. If there is more than one object in the area (which there usually is) the top of the window will say “Object (1 of #):”. There will be a name in the box on the same line, and an arrow indicating a drop down menu.
  - a. Click the arrow to see the list of objects in the area where you clicked
  - b. Select the object you want
3. You can also select an object by using Ctrl+f or “Find” from the Edit menu.
4. Check the magnitude to make sure the object you selected will be visible. Generally, magnitude 6 or less is good, 10 and dimmer are completely invisible.
5. To send the coordinates to the tcs, click the green Newtonian-style telescope icon at the bottom of the information window (“slew”).
6. After a few seconds, the window on the PC will close, “Slew Enabled” will blink on the bottom of the tcs screen and the coordinates will appear next to “NEXT OBJECT”.
7. On the tcs, select item 7 “Start slew”, check to make sure the telescope is clear, then hit enter. **DO NOT MOVE THE TELESCOPE IF SOMEONE IS LOOKING THROUGH THE EYEPIECE!** It’s all fun and games until someone loses an eye...
8. Rotate the dome so the telescope is looking out the opening.
9. If using a narrow field of view eyepiece, it may be necessary to center the object with the handpaddle

## Handpaddle Operations

There are two handpaddles, one in the dome and one in the control room. They are used for “manual” control of the telescope position, focus, and dome rotation. This is the best way to focus and to move the dome. You can also perform most of the handpaddle functions from menu items in the tcs software (page 12.)

### ***Focus***

1. The focus buttons are at the top of the handpaddle.
  - IN moves the secondary up away from the primary against gravity (moves the focal plane IN closer to the telescope body). This direction is preferred since gravity allows less play in the system.
  - OUT moves the secondary down closer to the primary (moves the focal plane OUT away from the telescope body)
2. The “focus” reading from the encoder on the secondary is displayed on the tcs screen. The limits are between 481 and 3752. 1 mm of secondary movement is approximately 161 units on the encoder.
3. When switching directions there is a slight hysteresis that will cause a 1 - 2 second delay before the mirror starts to move. If you are getting clearer images by tapping the focus buttons, the image clarity is being affected by atmospheric blurring. You may get better results by switching to a lower power eyepiece.
4. High speed focus motion is obtained by holding the SET button then pressing IN or OUT. If you release the SET button the focuser will slow. To resume high speed focus you must also release the focus button.
5. See the appendix for the eyepiece list with focus positions.
6. When you switch to a shorter focal length eyepiece (higher power), move the focus in.
7. To quickly return to a focus position, use the tcs: see Focusing on page 14.

### ***Moving the Telescope***

1. There are four direction buttons around the set button:
  - a. N move north to higher dec
  - b. E moves east, increasing RA
  - c. S south to lower dec
  - d. W west, decreasing RA
2. There are 3 speeds:
  - a. SLEW is the fastest for slewing or making major adjustments while looking in the finder
  - b. SET is a slower speed for minor adjustments in the telescope position
  - c. The telescope also moves at the “guide” speed, which normally tracks the motion of the sky.
3. To move the telescope, hold both the speed button and the direction button. E.g to move quickly east, hold down both SLEW and E. If only the direction button is pressed the ‘scope moves at the guide speed

## ***Dome Rotation***

Note, although the tcs does have the capability to rotate the dome and track with the telescope, it moves the dome too often and without warning, and may crash the tcs if the dome gets stuck.

Handpaddle control is the **ONLY** recommended way of moving the dome.

1. The dome rotation buttons are on the bottom of the handpaddle.
  - a. R turns the dome right (clockwise)
  - b. L turns the dome left (counter-clockwise)
2. The direction the dome is facing is listed as “DOME AZIMUTH” on the tcs screen. If you align the dome and telescope, you can control the dome from the handpaddle in the control room. See *Aligning the Dome* under *The Telescope control System* on page 14 for instructions.

# The Telescope control System

## ***Overview of the System***

This telescope is completely under computer control: one never moves it or the dome by hand except in an emergency. The computer hardware and software combination that control the telescope and dome are called the Telescope Control System (TCS).

Commands are sent to the TCS by means of the left hand keyboard in the dome or in the control room. It is possible (like most research telescopes today) to do all of the observing from the control room and never be in the dome.

1. The software is a menu driven system (see below), whereby one enters numbers to select an option.
2. The current state of the telescope (where it is pointing, if it is tracking, time, etc) is displayed on the left hand (monochrome) computer monitor.
3. Most commands need to be followed by Enter to be accepted.
4. In almost all cases, hitting the ESC key cancels the current command.
5. If no command is executing, ESC should send you up one level in the menu tree.
6. If the TCS is blinking SLEW ENABLED but not actually moving, enter 8 followed by Enter to revert to an idle mode.

## **The Menus**

In all menus, 0 (zero) will take you back to the main menu

### **Initialization**

1. Set date and time
  - Set the date and time for the tcs software. See Setting the Date and Time on page 15.
2. Set telescope position
  - Tell the tcs the coordinates the telescope is pointing to. Entering zero will cause the tcs to use the coordinates under NEXT OBJECT, which is usually the last set of coordinates entered. See Aligning the Telescope on page 6.
3. Set dome position
  - Tells the tcs where the dome is pointed. See Aligning the Dome on page 14.
4. Set rotator position
  - NA
5. Set focus position
  - Tell the tcs what number the focus should be at (Not Recommended: frequently causes the tcs to crash)
6. Open data file
  - NA You will need a low density single sided DOS formatted floppy...
7. Close data file
  - NA

## **Movement**

1. Set slew position
  - Tells the tcs what coordinates you want to point to. Requires RA, Dec and epoch. See Manual entry of coordinates: on page 17
2. Set offset
  - Tells the tcs to move the telescope to a position relative to the current position. See “Starhopping” on page 17
3. Select library object
  - Select an item from the Sommers-Bausch Observatory Catalog of Astronomical Objects. Items 1 – 109 are the Messier objects. Items 401 – 424 are guide stars with declinations on the 40s. Items 501 – 513 are the 12 brightest stars. For more on the library, see Using library objects: on page 16. See Also Aligning the Telescope on page 6.
4. Select table entry
  - If you have created a table under Set table entries in the Miscellaneous menu (below), you can use this command to select the items.
5. Set zenith position
  - Move the telescope to what the tcs thinks is zenith and sets the track rates to 0 so the telescope should stop tracking (note this does not actually turn off the tracking of the motors) See Stowing the telescope on page 7.
6. Start trail
  - Turns on the trail function, Used to move an object back and forth along the slit in a spectrograph. Set the speed using the rates menu (below).
7. Start slew
  - Makes the telescope move to the coordinates if “SLEW ENABLED” is blinking.
8. Stop
  - Overrides telescope motion. See Stopping the telescope on page 16.
9. Write data to file
  - NA

## **Rates**

1. Set track rates
  - Set the rate the telescope will track at. The first two entries should be the normal sidereal rate, 15 to 15.04 for RA and 0 for Dec. See Setting the rates below for more information.
  - If the TRACK/AUX TRACK switch on the blue box is set to AUX TRACK, the telescope will use the normal sidereal rate to slew then switch to the rates set in the entries beginning AUX to actually track the object. This can be useful for rapidly moving comets or for dark-side lunar photography.
2. Set handpaddle rates
  - Adjust the SET RATE (the speed the telescope will move when holding the SET button on the handpaddle) or GUIDE RATE (the speed the ‘scope moves if only the direction button is pushed.) See Moving the Telescope under Handpaddle Operation on page 10.

3. Set trail rates
  - Set the speed for using the trail function (see Start Trail under the movement menu above)

### **Miscellaneous**

1. Set switches
  - NA
2. Set display epoch
  - Change the display epoch (default is 2000)
3. Set table entries
  - Build a table of up to 40 objects, which can then be selected from Movement menu item 4. You need the RA, Dec and epoch for each object.
4. Move focus position
  - Adjust the focuser. See the Eyepieces table on page 40 for approximate positions. See also Focus under Handpaddle Operations on page 10.

## ***Using the TCS software***

### **Aligning the Dome**

To align the dome and telescope:

1. Make sure the “Dome” switch is down (NOT on Autodome – it should stay in this position, since the tcs has a tendency to crash with it on)
2. Point the telescope at a known object.
3. Center the dome opening on where the telescope is pointing.
4. Read the “TELESCOPE AZIMUTH” from the telescope position section of the tcs screen.
5. Go to the initialization menu.
6. Select item 3 “Set Dome Position”
7. Enter the same value as the telescope azimuth.
8. Answer “No” to “any changes?”
9. The “TELESCOPE AZIMUTH” and “DOME AZIMUTH” should now match. As the telescope tracks or when you move to another object you can control the dome from the control room by using the handpaddle and adjusting the dome azimuth to match the telescope azimuth. See Dome Rotation under Handpaddle Operations on page 11.

### **Focusing**

Miscellaneous menu item 4 allows you to move the focus. The limits are listed at the bottom of the screen when you choose this item. See appendix 7 for approximate positions for focusing with the different eyepieces. See the Focus section under Handpaddle Operations on page 10 for more on the focuser.

## Moving the telescope

To slew the telescope, see Controlling the Telescope Without TheSky on page 16.

To move the telescope a small amount, use movement menu item 2, Set offset (see “Starhopping” on page 17 for details on the format to use). This can be used if the handpaddle is not responsive, but it is not a very convenient way to operate. The Eyepieces table on page 40 will tell you the field of view if you are trying to get an object closer to center. If you are trying to restart the telescope, use movement menu item 5 to get back (close) to zenith.

## Setting the Date and Time

The date and time should be set at the DOS prompt when you start the tcs computer (see Starting Up on page 4.) Any changes you make inside the tcs software will NOT affect the computer clock. However, if you need to change the time, follow the steps below.

Differences of only a couple seconds will have little effect, but differences of less than a minute can cause problems with pointing and for the telescope limits. The tcs runs on UT, which is EST + 5h. The date changes at 0h UT. You can check the time at

<http://tycho.usno.navy.mil/simpletime.html>.

1. Select item 1 “Set date and time” from the initialization menu (page 12).
2. Enter the UT date and time (military/24 hour format) in the blanks provided. Include a few seconds lead time to execute the command.
3. Answer “No” to “Any changes” when the real UT equals the time you entered.

## Setting the rates

This should only be done if you are sure the track rates are not correct, or if you need greater precision (as for imaging). The rates will revert back to the programmed rates when the computer is rebooted.

1. Select item 3 “Rates menu” from the main menu page
2. Select item 1 “Set track rates”
3. Set the RA rate to 15.00 if it isn’t set to that already. Otherwise, try 15.04, or something in between. All other rates should be zero.
4. Answer “No” to “Any changes”
5. Go back to the movement menu, point the telescope at a star, and make sure the telescope is tracking correctly. You may need to adjust the RA rate again to get the tracking rate right.
6. If you had to change the rates because the telescope wasn’t tracking normally, report the problem.
  - To track something that doesn’t move at the sidereal rate, use AUX TRACK. To enable this, set the rates (see Rates under the tcs menu on page 13), then flip the TRACK/AUX TRACK switch on the front of the blue box to AUX TRACK. Please be sure to flip the switch up when you finish!

## Stopping the telescope

- Movement menu item 8 “Stop” will stop the telescope in mid-slew. It will override the handpaddle, but only as long as the buttons are pressed. It does not stop the telescope from tracking, and it will not prevent the telescope from tracking into the limits. See also, Movement under the tcs menu descriptions on page 13.
- To stop the telescope tracking, do one of the following: Set the track rate to 0 (see
- Rates under the tcs menu descriptions on page 13, or Setting the rates below); use movement menu item 5, “set zenith position” (see Movement under the tcs menu descriptions on page 13); or set the Track switch on the front of the blue box to OFF.

## Controlling the Telescope Without TheSky

### Using library objects:

Movement menu item 3 “Select Library Object” lets you select an object from the tcs library. This is normally used to align the telescope.

1. Determine which library object you want to use:

- The library is the Sommers-Bausch Observatory Catalog of Astronomical Objects. More information on this catalog (including the object lists) are available from the Sommers-Bausch Observatory at <http://lyra.colorado.edu/sbo/manuals/sbocatalog/sbocatalog.html>.
- An overview of the library:

Catalog	Library number	Numbering system
Messier	001 – 109	Messier catalog number
Mullaney & McCall	201 – 305	M&M number + 200
Ephemeris Star List	401 – 424	RA to nearest hour + 400, dec between 40 & 50°
Bright Star List	501 – 513	Brightest star order + 500
Special Objects	514 - 528	513 + next SBO object

2. Select item 3 from the movement menu.
3. Enter the number of your chosen library object.
4. Answer “No” to “Any Changes?”.
5. The coordinates of your library object should appear on the “Next Object” line and “SLEW ENABLED” should blink at the bottom of the screen. If “Target out of Range” appears on the screen, the object is outside the pointing limits of the telescope. Press <esc> and go back to step 1 and choose a different object.
6. To cancel your selection press <esc> any time before slewing the telescope.
7. Select item 7 “Start Slew” and press <Enter> to slew to the object.

## Manual entry of coordinates:

Movement menu item 1 “Set Slew Position” lets you enter the coordinates by hand. You need to know the RA and dec of the object, and the epoch for the RA and dec. Lists are frequently published for epoch 2000, while software usually gives the coordinates for the current year. The Messier catalog is in the appendix, although these objects are also in the Library (see above).

1. Select item 1 from the movement menu.
2. Enter the RA in the format hh mm ss.s
3. Enter the dec in the format dd mm ss.s
4. Enter the epoch in the format yyyy.y (it says 19xx.x, but it will take 20xx.x)
5. Answer ‘No’ to “Any changes?”
6. The coordinates you entered should appear on the “Next Object” line and ‘SLEW ENABLED’ should blink at the bottom of the screen. If “Target out of Range” appears on the screen, the object is outside the pointing limits of the telescope. Go back to step 1 and enter a different set of coordinates.
  - The pointing limits are roughly  $+90^\circ$  to  $-35^\circ$  in dec. For objects with a dec less than  $47^\circ$ , an R.A. limit of roughly the sidereal time  $\pm 5$  hours is a good estimate, although lower decs will have a smaller visibility range.
7. To cancel your selection press <esc> any time before hitting <Enter>.
8. Select item 7 “Start Slew” and press <Enter> to slew to the object.

## “Starhopping”

Starhopping is the most common way to point a non-computer-controlled telescope, such as the C8s. It is not very convenient for the 0.4 m, but it is the most straightforward way to operate.

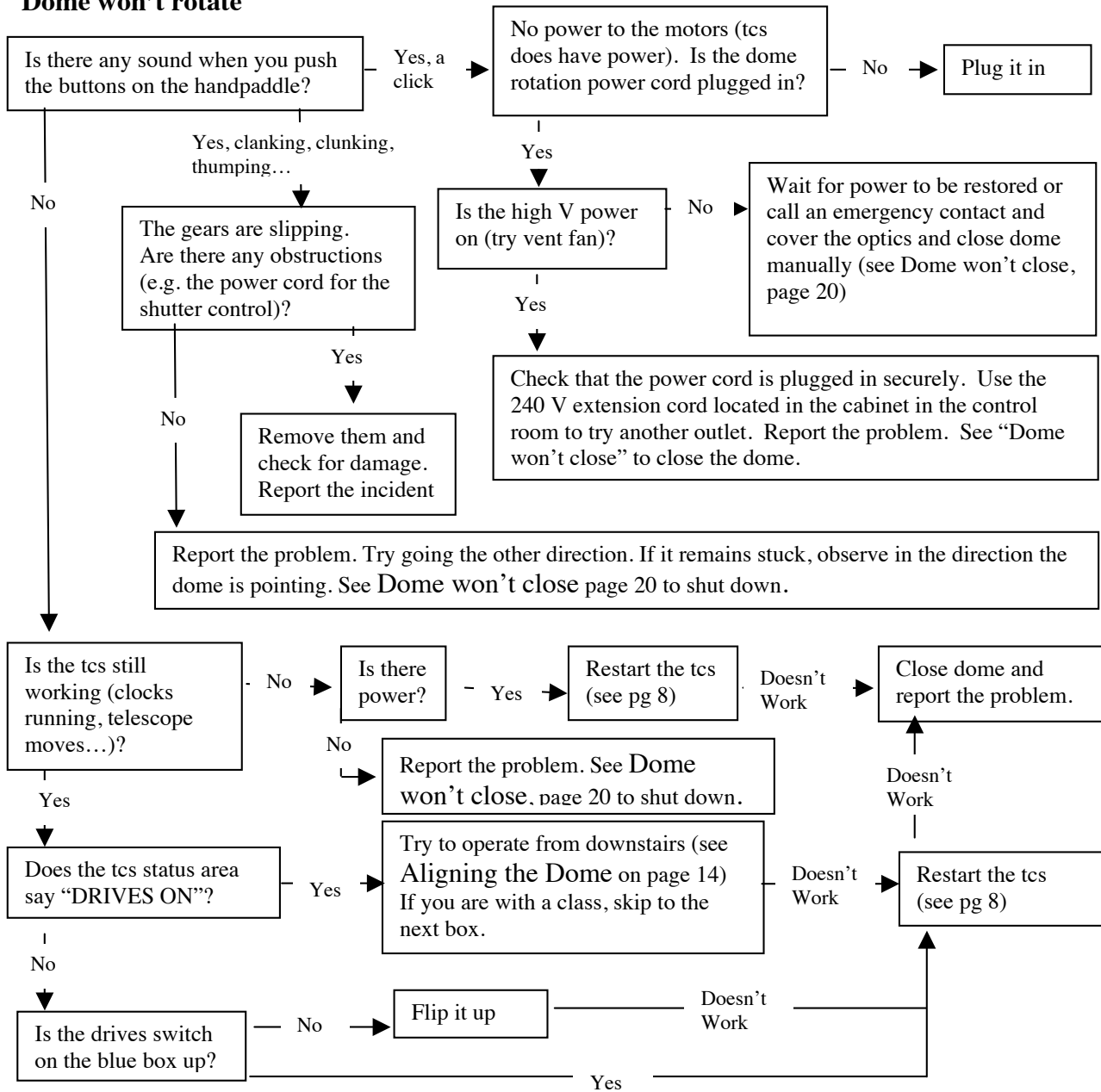
1. Choose a target object.
2. Find a bright object nearby. Determine the difference in RA and dec from the bright object to your target. Convert these values to arcsec.
3. Using the handpaddle, center the bright object in the finder, then in the 35 mm eyepiece.
4. Use movement menu item 2 “Set offset” to enter the change in RA and dec to get to the target in arc seconds (999.9 maximum).
5. Use movement menu item 7 “Start slew” to slew to the new object.
6. If necessary, use the handpaddle to center the object.

# Troubleshooting

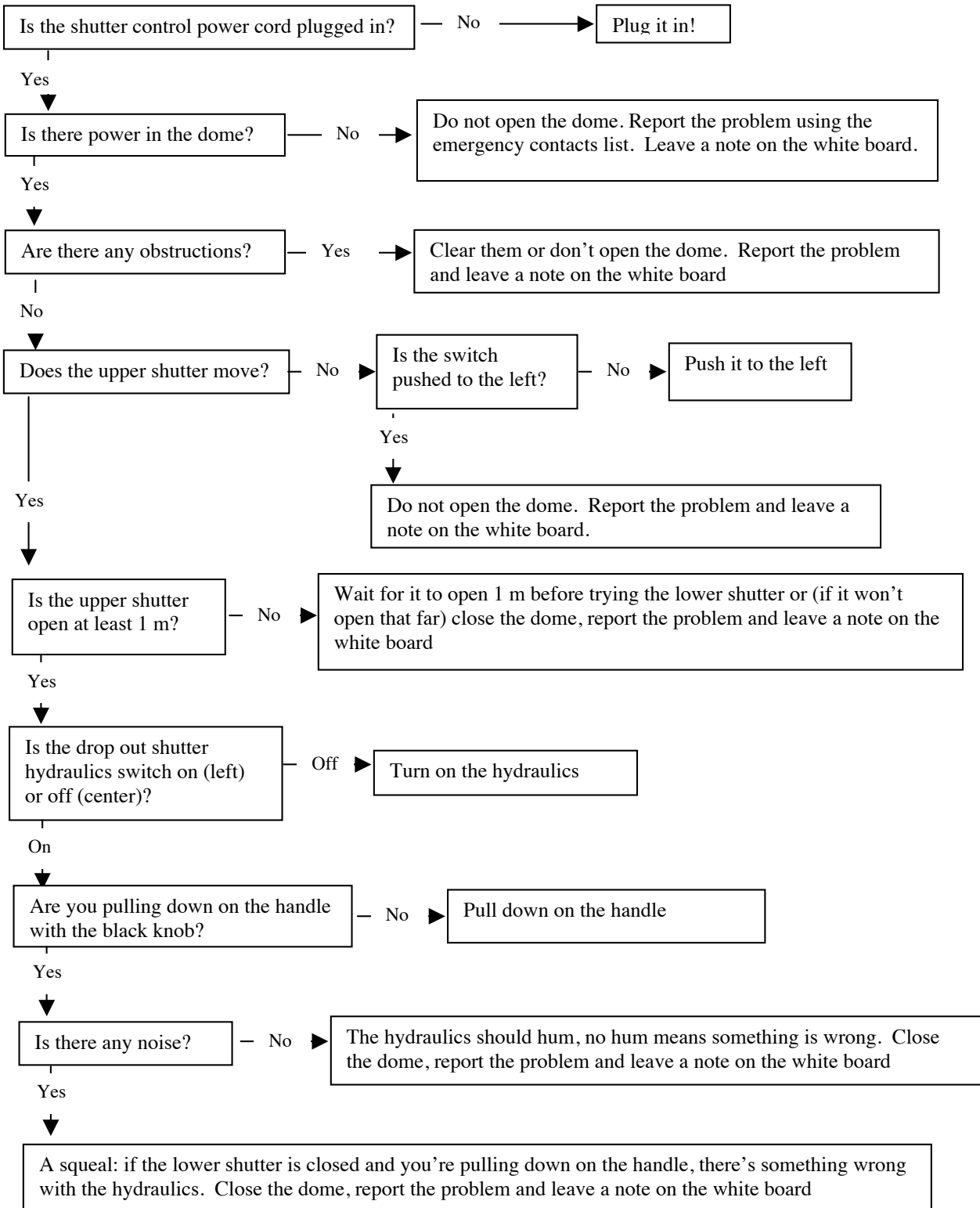
If you have any trouble that you cannot completely resolve, report the problem via the web or email (see “Reporting Trouble” on the last page) and leave a note on the white board so others aren’t surprised if they encounter the same problem. If it is an urgent issue such as being unable to get the telescope upright or unable to close the dome, please do not leave until you have gotten hold of someone from the emergency contacts list.

## Issues With the Dome

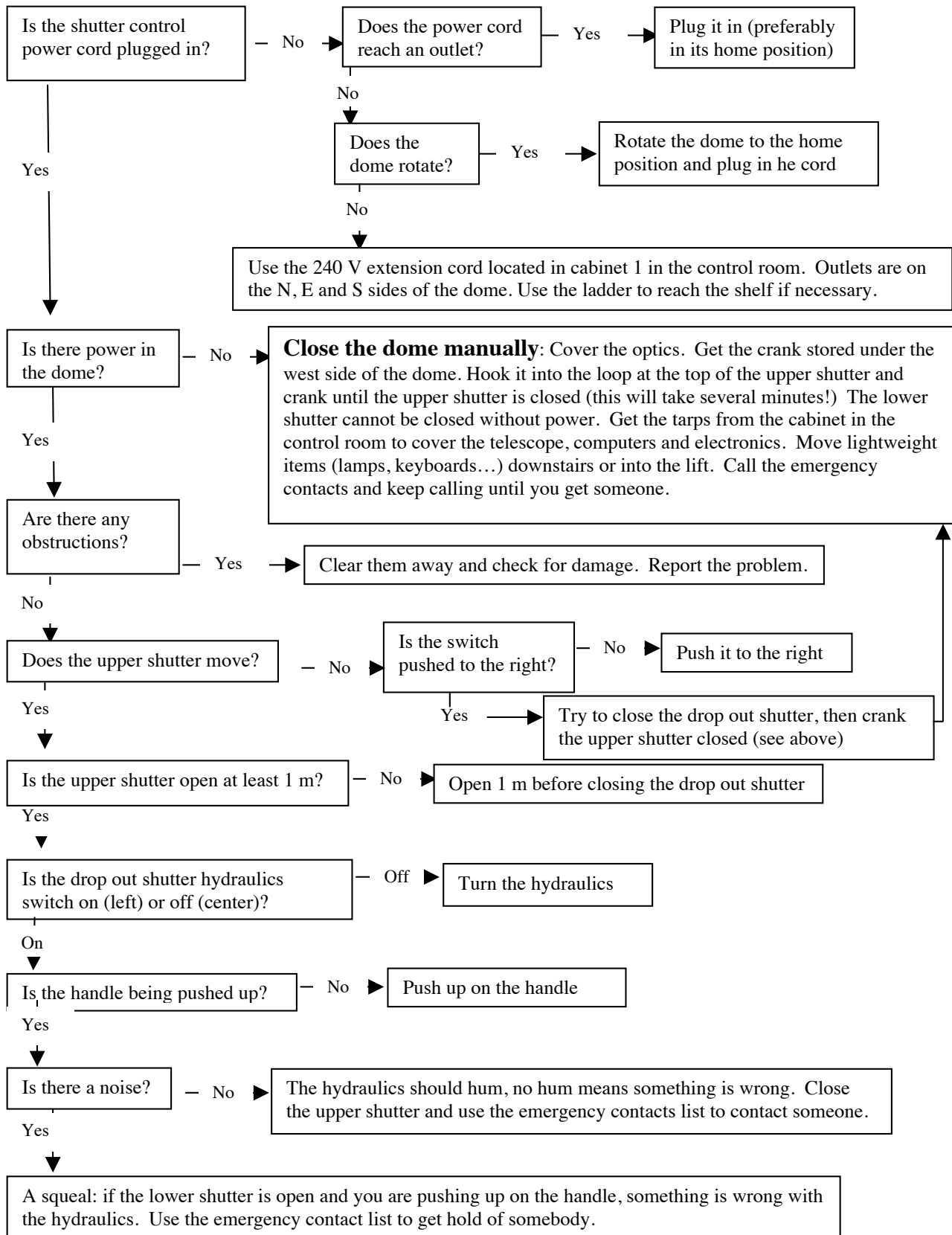
### Dome won’t rotate



## Dome won't open

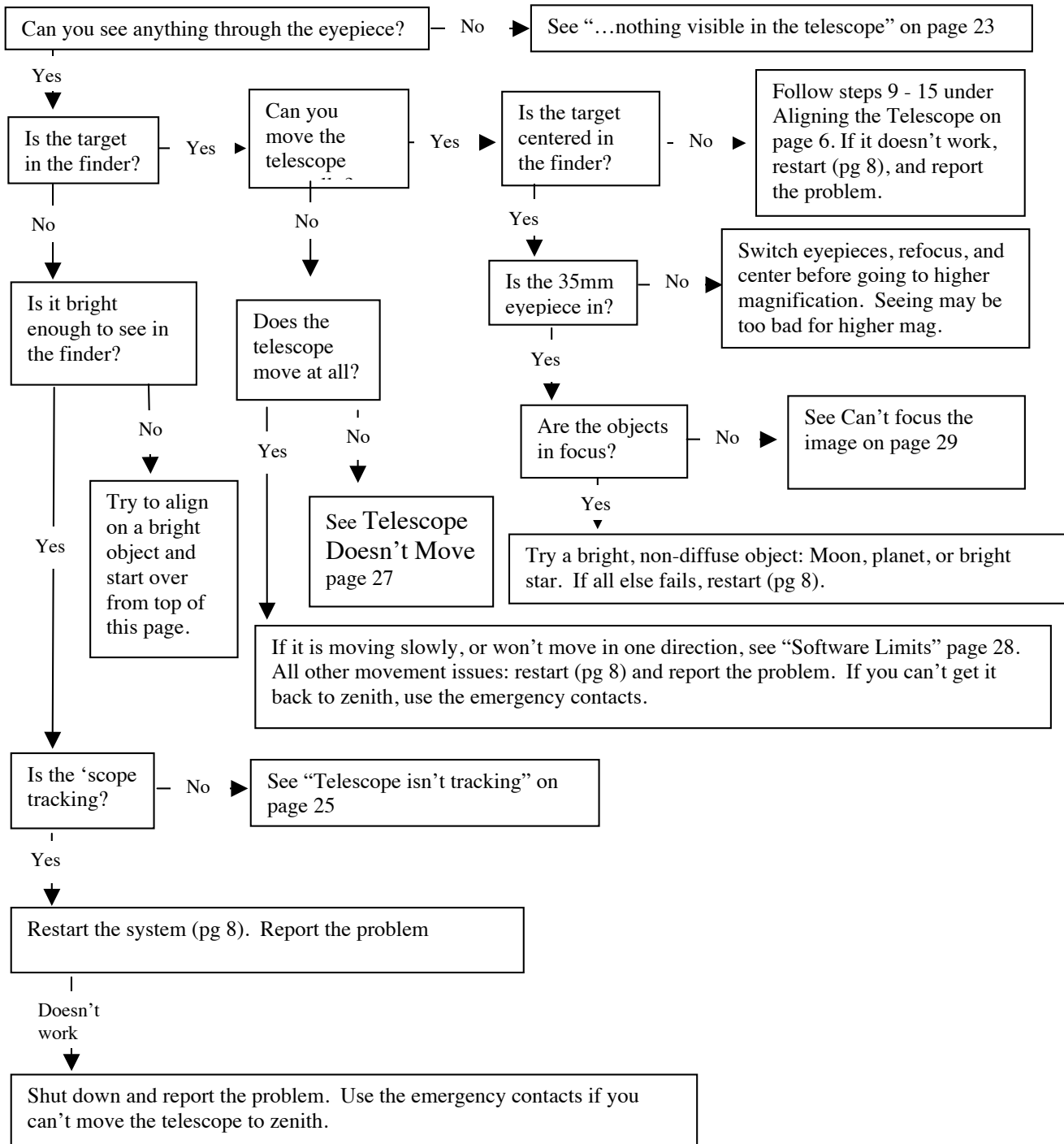


## Dome won't close

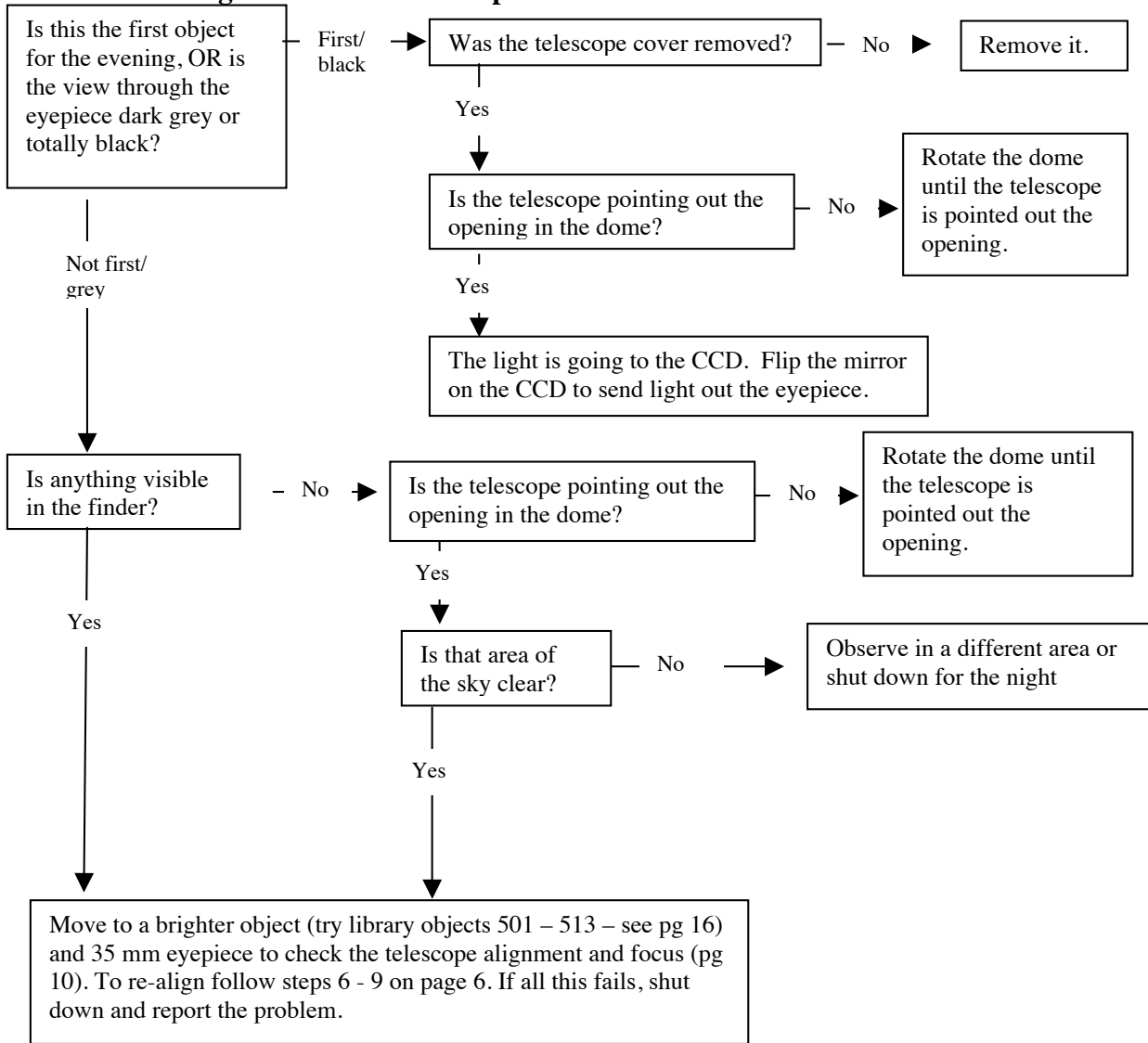


# Telescope Pointing Problems

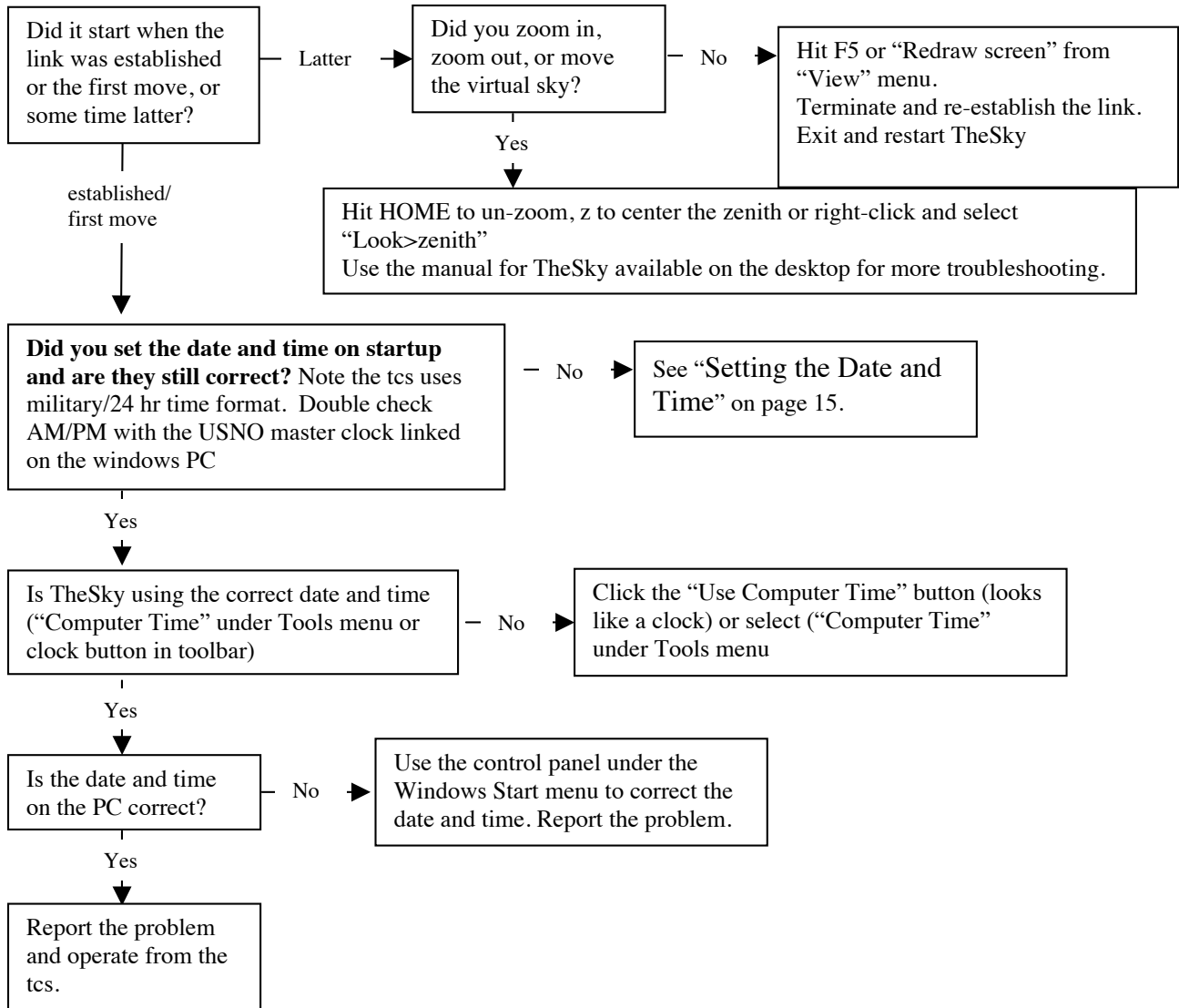
## The target is not in the field of view of the main telescope



### There is nothing visible in the telescope

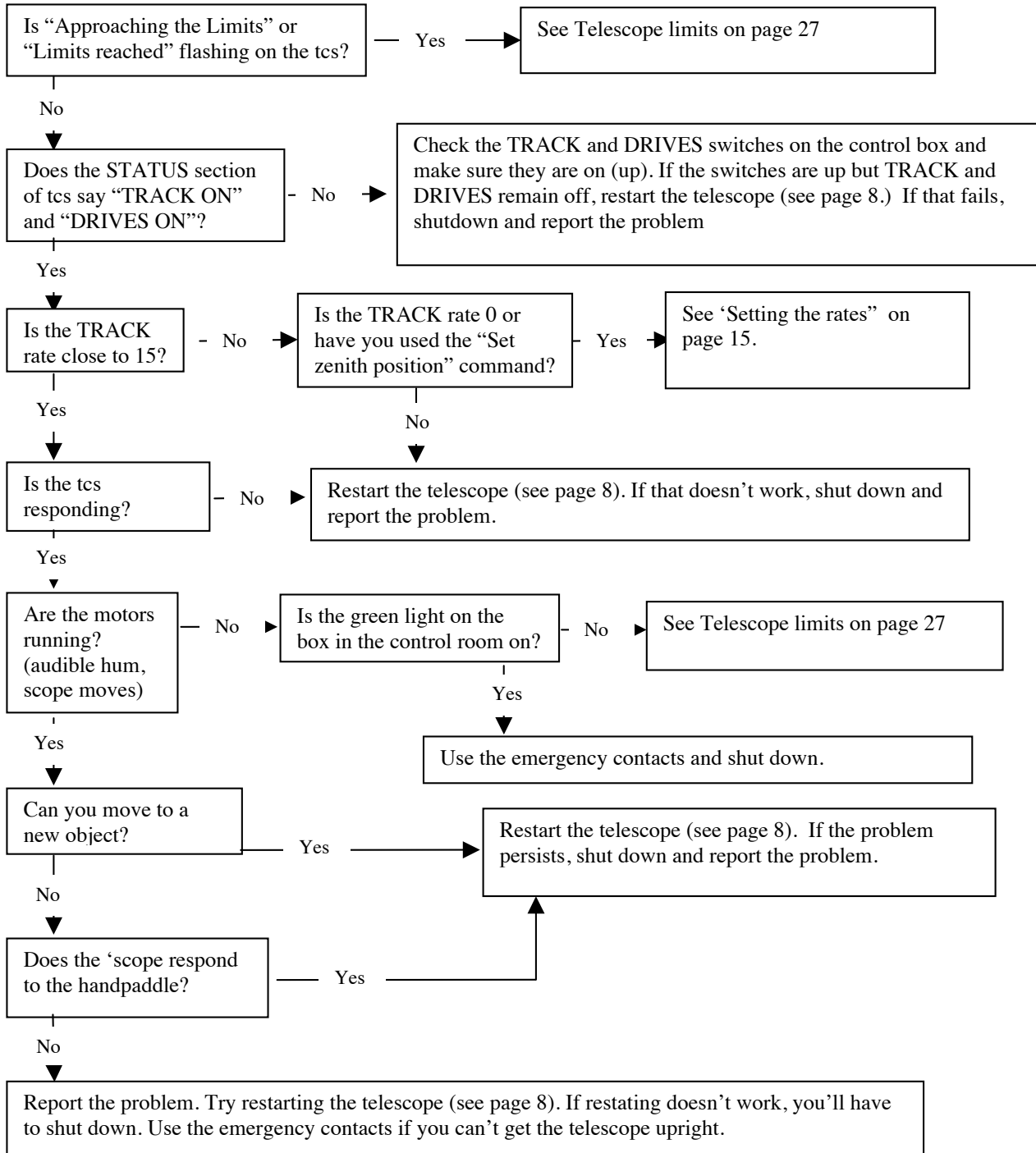


## The crosshair on TheSky does not match where the telescope is pointing

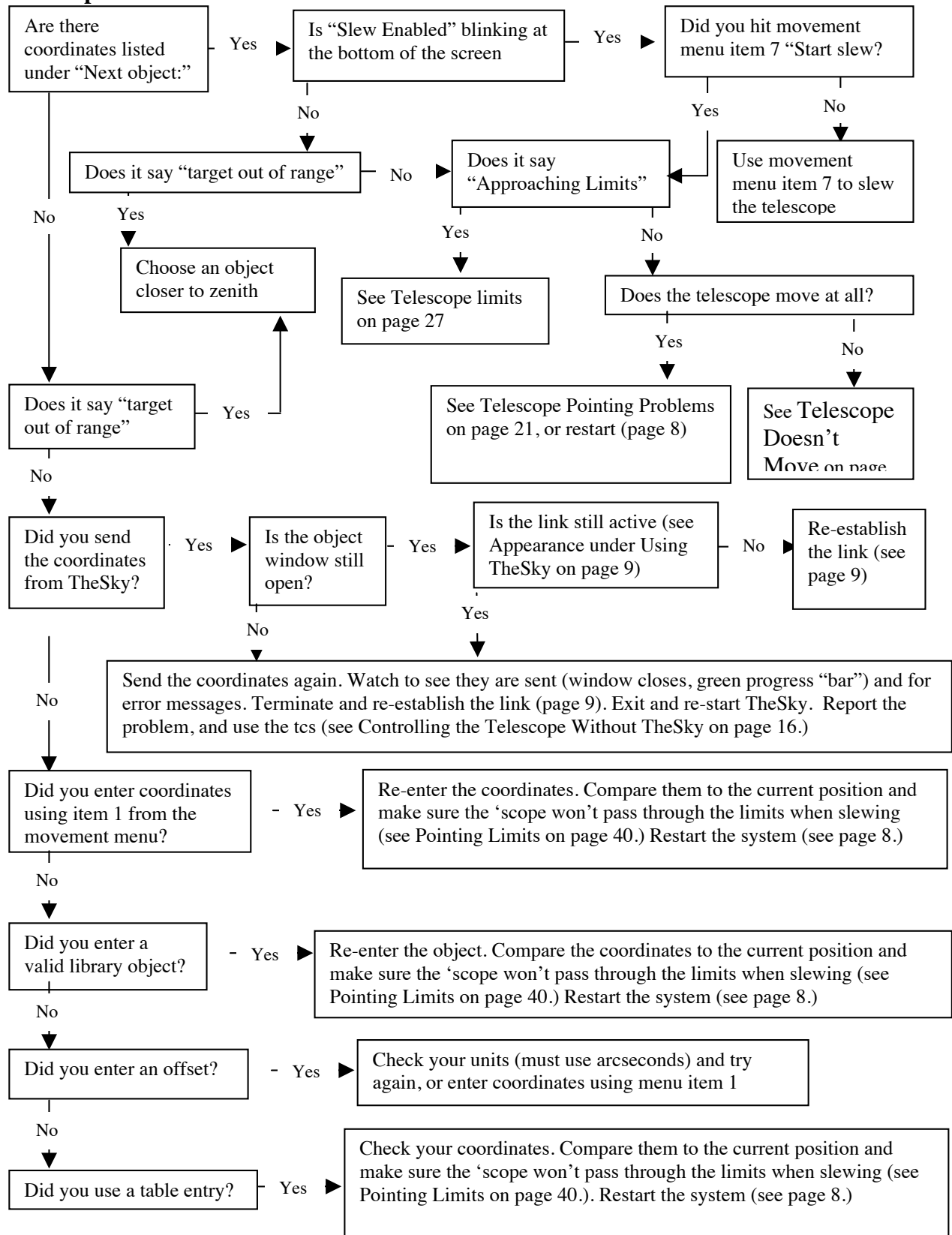


## Problems With Telescope Motions

### Telescope isn't tracking

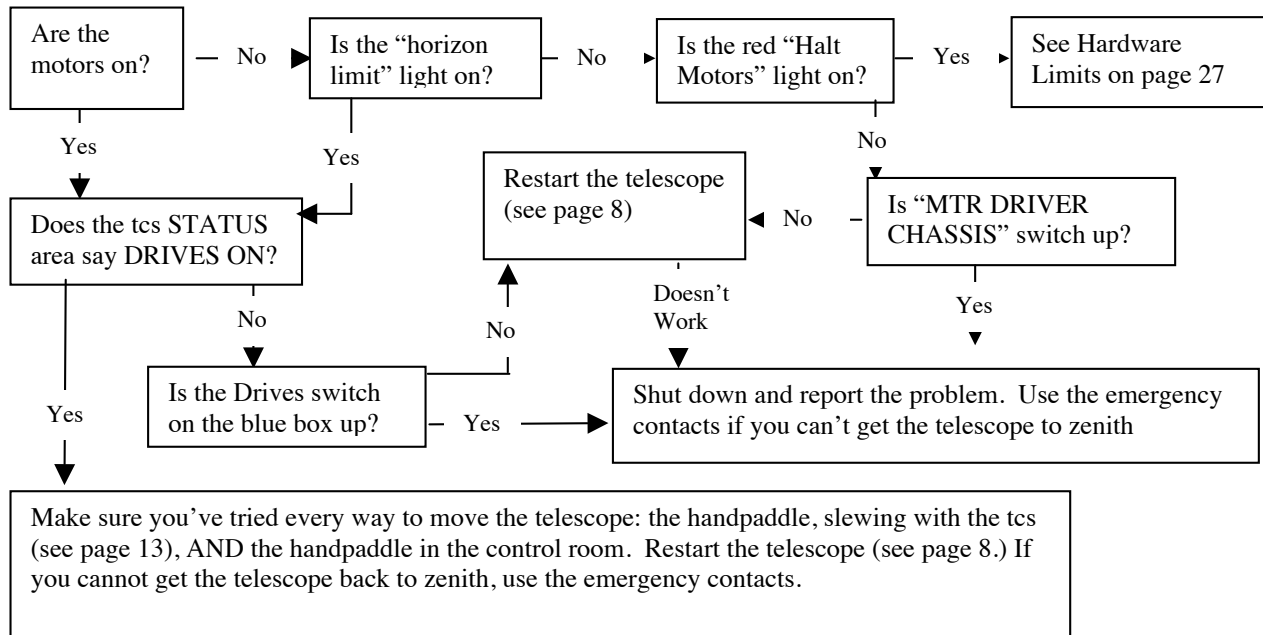


## Telescope doesn't slew to new coordinates

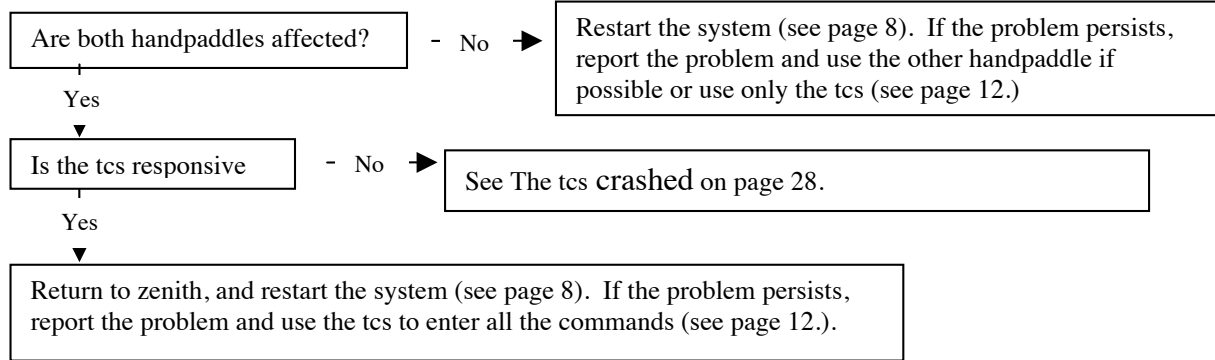


## Telescope Doesn't Move

NOTE: if the telescope won't slew but does move for the handpaddle, see the section above. If it won't move for the handpaddle but will move when you enter coordinates, see the section below.



## Telescope doesn't respond to Handpaddle



## Telescope limits

### Software limits

The telescope will not normally allow you to enter coordinates that will cause the telescope to end in the software limits. However the software can cause the telescope to try to pass through the limits as it slews to the target. It can also track into the limits.

As you approach the software limits, “APPROACHING LIMITS” flashes on the tcs screen and the ‘scope moves at half speed.

If the telescope is slewing

1. Release the handpaddle buttons or use movement menu item 8 “Stop” to stop the telescope from slewing.

Once you hit the limits, “LIMIT REACHED” will flash below “APPROACHING LIMITS”, the telescope will not slew any farther in that direction. It may continue to track however, so it important not to leave it at the limits west of the meridian.

To get out of the software limits:

1. Look at the position of the telescope or the white target on TheSky to determine the best way to get the telescope pointed closer to zenith.
2. Hold SLEW and the appropriate direction button on the handpaddle to move the ‘scope toward zenith.
3. Once you clear the software limits, “APPROACHING LIMITS” stops blinking. Release the handpaddle, and resume normal operation. Note the telescope doesn’t resume normal movement until you release the handpaddle.

### Hardware Limits

Although the software limits make this nearly impossible, you could hit the **Hardware limits**. The most common reasons this occurs are slewing due north when taking off the cover, or not entering the date and time accurately on startup. The telescope can also track into the hardware limits.

If you hit the hardware limits, the motors will shut off, and the green light on the front of the box in the control room will be off. *The green light is the only sure way to tell.*

To get out of the limits:

1. In the control room, push in red HALT MOTORS button.
2. Back in the dome, push front end of scope ~1” toward zenith by hand. Nothing will appear to happen, so don’t push it again until you check for the green light!
3. In the control room, the green light should come on. If it is, release the red Halt Motors button. If not, go back to the dome and push the ‘scope another inch.
4. DO NOT move the telescope more than 3 - 4 inches (5 – 7 cm, about a handspan). If the green light doesn’t come on, use the emergency contact list to get hold of someone for help! Do not leave the telescope sideways.
5. Restart the Telescope (page 8).
6. Report what happened. Someone will need to check the drive belts to be sure they are ok.

## **Other Problems**

### **The tcs crashed**

When the tcs crashes, it usually shows up as a short string of letters and numbers in the upper left corner of the display, and the handpaddle usually continues to work.

Follow the steps under Restarting on page 8 to get the telescope back to a working state.

### **Can't focus the image**

1. Poor seeing conditions can cause objects to look out of focus. Higher magnification will make it worse. Having the control room door open or not letting the telescope cool also make it difficult to focus.
2. Remember there is about a 2 second lag when changing direction using the handpaddle.
3. Use Miscellaneous menu item 4 to return to a focus position that worked, or a position from the table in the appendix.
4. If the focuser actually isn't working, report the problem.

### **(Windows) PC Problems**

#### **The terminal you're at doesn't work, but the other one did**

Make sure the monitor is turned on.

Check the main KVM box in the control room: both lights should be lit. If not, report the problem and reset the KVM: unplug the box that isn't working, count to 5 and plug it back in.

If resetting the KVM doesn't work or you don't want to play with it, work without the PC and report the problem and the steps you tried to fix it.

#### **If the PC won't boot:**

Check the white board for messages

Make sure the power strip and monitor are on and the power cords are plugged in.

Either email astro-labs or use the web form to report that the computer won't boot (use the lab macs)

#### **If you can't log in:**

Check the white board for messages.

Check the user name and password on the bulletin board (remember, this is NOT your username!)

Check the domain (should be "this computer")

If you're sure you're typing it in right and have the right domain, either email astro-labs or use the web form to report that the computer won't let you in. You can also email astro-help.

#### **TheSky won't link to the tcs**

Make sure the tcs is on and the telescope is running

Note any error messages and either email astro-labs or use the web form to report that you can't link to the telescope.

Use the info window in TheSky to get the RA and dec, then operate from the tcs (see Controlling the Telescope Without TheSky on page 16.)

## **Appendix 1: Taking Images With the CCD Camera**

*This information is provided as a quick reference only for operators already familiar with the camera and CCD imaging. The CCDSOft manual is on the desktop, and there are several hardcopies of the manual for the previous version.*

Note the camera is designed for deep sky objects. Daylight images are difficult (e.g. Venus at sunset), and the telescope should NEVER be pointed at the Sun.

### ***Turning the Camera On and Setting up***

1. Start the CCDSOft program on the PC.
2. Turn on the power strip on the pier in the dome
3. Use the 35 mm lens to focus on an object (its focal length is close to the camera's)
4. Use the round knob above the camera aligned with the eyepiece to flip the mirror to send light into the camera. The view through the eyepiece should be black
5. If the "Camera Control" window isn't open, open it by choosing "setup" from the "camera" menu, or typing "Ctrl+W"
6. The camera and filter wheel should already be selected. If not, the appropriate settings are on the bulletin board over the PC.
7. Click "Connect" to connect to the camera. If you get a "SBIG driver: Camera not found" the power strip is not on. Turn the power strip on and try again. If the power strip IS on, there is something wrong with the connection and you need to report the problem.
8. Click the "Temperature" button to get the temperature control window. Select the temperature setpoint (0° C is the default, -10° C is recommended) and click "On" to start the camera cooling.
9. Click the "AutoSave" tab and make sure autosave is turned on. The default file should be C:\Data.
10. When the temperature has reached the operating temperature, you are ready to start taking images.

### ***Shutting Down***

1. Save any work you want saved. C:\Data is a temp directory and is periodically cleaned out.
2. Click the "Temperature" button and turn off cooling.
3. Click the "Disconnect" button to disconnect from the camera.
4. Turn off the power strip
5. Flip the mirror so the light goes out the eyepiece.
6. Exit CCDSOft.

## Capturing the Image

The camera is an SBIG ST-8 with a Kodak CCD. The chip has 9 micron square pixels in a 1530X1020 arrangement. The telescope scale is 53.4"/mm, and the field of view is 14.55x9.7"

1. Click the "Take Image" tab.
2. Set your exposure time.
3. If you want a delay, set the delay time.
4. If you want more than one image of the same object with the same exposure, choose a number from the dropdown list next to "Series of:"
5. Choose the filter you want to use: B, V, R, I or Halpha. You'll have give the camera a moment to change the filter.
6. Choose whether you want the frame to be light, Bias, Dark, or a flatfield. If you do a light frame, choose what kind of reduction you want from the drop down list (note we do not have a screen at this time.)
7. When you are ready, click "Take Image"
8. The image will open in the CCDSoft window. You can edit it in that window, or export it to your own folder to edit latter.
9. If you want to take a subframe, draw a square around that area you want to take the subframe of, click "On" and set the bin size:

Binning factor	Pixel Size (")	Readout time (sec)
1	0.57	58
2	1.14	19
3	1.71	11

10. To focus:
  - a. set an appropriate exposure time and take a single exposure
  - b. click the autosave tab and turn off autosave
  - c. draw a box around a star in the field from the first image
  - d. click the focus tab, make sure the subframe and binning are correct and click "take image"
  - e. adjust the focus (you'll probably need to use the handpaddle) until your image looks good and the sharpness graph is at its maximum.
  - f. Turn autosave back on before going back to the "take image" tab.

## Appendix 2: Binoculars

There are several pairs of binoculars available in the cabinet in the control room. Because binoculars are easy to walk off with, we've developed a procedure for using these in a class so that we don't lose them (again).

1. Decide how many you want to take out and find that number of responsible students
2. Get the students drivers licenses or state issued ID (they need it more than their college ID and it is illegal to take a credit card or similar item)
3. Place the first license in the card wallet section "1". Give that student binocular #1. Make it clear to that student that (s)he is responsible for that pair of binoculars.
4. Place the second license in section 2 and give that student binocular #2 along with the responsibility warning, the third in section 3, etc.
5. Record the binocular use on the paper inside the door of the cabinet.
6. At the end of the observing session, give the students their IDs only after you get back the binoculars you loaned to them.
7. Report any missing binoculars along with the full name of the student responsible for them to the angel hall trouble report (via web form or email) and to the professor in charge of the lecture section (unless it was for Ast 127)

A note on personal use of binoculars: we would rather have the binoculars used and cared for than collecting dust. However, labs get first priority, so do not take the binoculars on a lab night if there is **any** possibility of them being used for class, and do not take them off campus for an extended period. You become personally liable for any binoculars that go missing or are damaged while in your possession. If labs ever have any problems with not having enough binoculars, this policy will change.

Make sure you sign out the binoculars on the sheet inside the cabinet door. **Binoculars that are not signed out will be reported stolen!**

## Appendix 3: C8 use and care

Used properly, the C8s are excellent 'scopes (and in windy, hot or cold weather may offer better views than the 0.4-m!) Be careful not to over-tighten the RA lock: it should be snug, but it will not prevent you from forcing the 'scope to move.

The Outreach 'scope in the control room can be taken into the classrooms or borrowed for outreach events by emailing astro-outreach or filling out the form on the astronomy department outreach page about the event and following the directions on the paper over the telescope.

### **Setting up**

1. The RA lock should be unlocked for storage. Lock it before trying to mount the telescope on the pier. Hold the C8 by the arms when moving it around. Carry it by the arm that does NOT have the dec lock (so you don't bend the dec lock rod).
2. Take the C8, power cord and eyepiece case out to one of the piers on the roof deck. You may or may not want the flashlight and a step stool.
3. Set the C8 on its side on the ground.
4. Locate the mounting bolts in the eyepiece case.
5. Screw one of the mounting bolts 2 - 6 turns into the **top** bolt hole (the one above the two motors, not beside them)
6. Place the other 2 bolts on the pier in easy reach when you get the 'scope up there.
7. Hold the telescope by the arms and slip the bolt into the open notch on the wedge. It is easiest to see what you're doing from the south side of the pier, but you'll have better leverage and control of the 'scope from the north side.
8. Keep one arm under the 'scope at all times in case the top bolt slips.
9. Rotate the scope until the other holes in the base of the scope line up with the wedge, and insert the other 2 bolts.
10. Tighten down all 3 bolts.
11. Remove the eyepiece cap and insert the diagonal. Make sure all the set screws are tightened (some 'scopes have 1, some have 2)
12. Insert the 40mm eyepiece in the diagonal and tighten the set screw.
13. Remove the blue lens cover and tuck it and the eyepiece cap into the lens case. Release the dec lock and the RA lock.

14. Center the telescope on a terrestrial object like the flag on top of the union and lock the dec lock and RA lock. **IMPORTANT:** the RA lock is locked when it is snug but not tight. It will NOT prevent you from moving the telescope by hand, but the 'scope should not move when nudged. The fine adjustment knob should move easily. Tightening it too far will strain the motors and warp the lock plate, preventing the telescope from locking at all.
15. Check the finder for alignment. If the finder isn't aligned with the main 'scope, adjust the set screws on the finder to bring it into alignment. The more precisely you perform this step, the easier the rest of your night will go!
16. Plug in the power cord.

### ***Shutting Down***

1. Unplug the power cord and replace the blue lens cover.
2. Release the set screws and remove the eyepiece and diagonal. Stow them in the lens case and put the eyepiece cap in the telescope.
3. Release the dec and RA locks and move the telescope to its storage position (tube aligned with arms, dec lock on east side, finder on top). Engage the RA and dec locks again.
4. Place one arm under the telescope just in case anything happens. Remove the two bottom bolts and set them on top of the pier.
5. Loosen the top bolt 2 or 3 turns. Hold the C8 by both arms and lift to slide the bolt out of the slot.
6. Set the C8 on the ground and remove the bolt. Stow all 3 bolts in one of the eyepiece holes in the eyepiece box. **DO NOT LEAVE THEM LOOSE IN THE SECTION WITH THE DIAGONAL.**
7. Place the C8 in its locker. The C8s, cases and lockers are all numbered.
8. Release the RA lock.
9. Place the eyepiece case, power cord and flashlight in with their C8 (different 'scopes have different power cords and bolts, so make sure the telescope, case and power cord all go into the right locker!)

## ***Night Observing***

### **Naked eye objects**

1. Identify the object in the sky
2. Release the RA and dec locks so you can move the 'scope.
3. Close one eye and sight down the tube to get the 'scope aimed in generally the right direction
4. Center the object in the finder. When it is close to centered, lock the RA and dec locks. Do not force the locks.
  - a. When the RA lock is locked it should feel snug, but may not be as far as you can move it. You can force the scope to move, but it shouldn't be easy. The fine adjustment knob should turn easily. **TIGHTENING THE RA LOCK TOO FAR CAN WARP THE PLATE INSIDE AND PUT STRAIN ON THE MOTORS!** The 'scope may not track right, and after repeated over-tightening it won't lock properly no matter how far you move the lever.
  - b. If you have any trouble with either the RA or dec locks, especially if they don't tighten or hold properly, please report the problem. Be sure to note the telescope's number.
5. Use the fine adjustment knobs to center the object in the finder 'scope
6. Check the position in the 40 mm eyepiece. Use the fine adjustment knobs to center it if necessary.
7. The focus knob is on the back near the eyepiece on the side opposite the dec lock. Turning it clockwise moves the focus out for longer focal length eyepieces.
8. Work you way up to shorter focal length (higher magnification) eyepieces, re-centering and refocusing each time to avoid losing the object.

### **Dimmer objects**

1. Determine the RA and dec of your target
2. Find a nearby bright object with the same dec as the object you want to find
3. Center the bright object in the finder and in the 40 mm eyepiece. Lock both the RA and dec.
4. Move the setting circle on the base of the telescope until it reads the right RA. There is a scale under the RA lock to do this.
5. Release the RA lock and move the 'scope to the RA of your target.
6. If the target is bright enough, center it in the finder 'scope. Otherwise, you may have to do some hunting with the 40 mm eyepiece. Note that since the wedges are not perfect (hence the dec alignment is not perfect) it is not recommend that you try to view anything you can't see in the 4.0mm.

## **Solar Observing**

USE CAUTION WHEN OBSERVING THE SUN! Permanent damage can occur in less than a second looking through an unfiltered telescope. Always make sure the front of the finder 'scope is covered. The light through it is strong enough to cause a burn or even set hair on fire while someone is looking through the main eyepiece.

### **White Light Filter**

2. Make sure the telescope you use has a cover on the FRONT of the finder. 'Scopes 4 and 5 should have covers. If not, there should be a spare in the case with the H-alpha filter. If you use the spare, be sure to report it.
3. Follow steps 1 - 10 on page 32 to set up the C8
4. Point the telescope AWAY from the Sun. Remove the blue cover
5. Fit the reflective white light filter over the front end of the telescope, being careful the foam pieces don't get caught on the rim. Make sure the filter is on all the way and is secure.
6. Once the filter is on, put in the diagonal and 40 mm eyepiece.
7. Use the telescope's shadow to align it. The shadow of the finder is the easiest to use: the shadow should be a dark circle (the finder 'scope) inside a dark ring (the holder for the finder 'scope) with a light band all the way around except where the screws go through. If you are VERY CAREFUL, you can take the finder cover off and align the image of the Sun with the shadow, but remember that image WILL burn if you get too close, and you should NEVER EVER look through the finder at the Sun!
8. Use the 40 mm eyepiece to get the Sun in the telescope. Then you can switch to a higher magnification eyepiece to observe sunspot regions.

### **H alpha filter**

The H alpha filter needs about an hour to warm up for good images. You may want to plug the filter in ahead of time so it will be ready when you are.

1. Make sure the telescope you use has a cover on the FRONT of the finder. 'Scopes 4 and 5 should have covers. If not, there should be a spare in the case with the H-alpha filter. If you use the spare, be sure to report it.
2. Follow steps 1 - 10 on page 32 to set up the C8
3. Point the telescope AWAY from the Sun. Remove the blue cover
4. Fit the red aperture stop filter over the front end of the the telescope, being careful the foam pieces don't get caught on the rim. Make sure the filter is on all the way and is secure.
5. Remove the visual back (the black thing the diagonal goes in) by unscrewing it from the tube.
6. Attach the visual back to the H-alpha filter.

7. Screw the H alpha filter onto the telescope. It should screw on easily if it is lined up properly. If not, try backing the ring off and re-aligning the filter. DO NOT force it.
8. Plug the H alpha filter in to the outlet on the pier. Please make sure the cord is wrapped around the pier and out of the way. You should get a message telling you the filter is a “.8A quantum PE” and the lamp should be amber. The display should change to display a wavelength . If it says “Error” or if the lamp is red, something is wrong and you should report the problem.
9. Insert the diagonal and eyepiece.
10. Use the telescope’s shadow to align it. The shadow of the finder is the easiest to use: the shadow should be a dark circle (the finder ‘scope) inside a dark ring (the holder for the finder ‘scope) with a light band all the way around except where the screws go through. If you are VERY CAREFUL, you can take the finder cover off and align the image of the Sun with the shadow, but remember that image WILL burn if you get too close, and you should NEVER EVER look through the finder at the Sun!
11. Use the 40 mm eyepiece to get the Sun in the telescope. Then you can switch to a higher magnification eyepiece to observe sunspot regions.
12. The red and blue buttons on the filter allow you to shift the wavelength: blue to a shorter wavelength, red for a longer. This can help make some features clearer. For example, shifting to a little shorter wavelength will make the granulation clearer on the side of the Sun approaching you.
13. To improve the view:
  - a. Make sure the filter is plugged in for half an hour minimum on a warm day, longer for colder days
  - b. You may want to adjust the wavelength to try and get a better view, but give it at least 2 minutes to adjust to your changes
  - c. The eye relief is better with a lower magnification. If students are having trouble seeing anything, you might try a longer eyepiece (40 mm is the longest)

## **Appendix 4: History**

The Observatory on the roof of Angell Hall is the latest in a series of facilities at the University of Michigan to instruct students in observational astronomy. The first Students' Observatory was constructed in the late 1870's close to the Detroit Observatory, and had a 6" refractor on an equatorial mount and a 3" transit circle. Optics for both were supplied by the Clarks. The building was torn down in 1923, and the mount for the refracting telescope was taken to South Africa to be used for site testing for the Lamont-Hussey Observatory. The 6" Clark lens later was used as a finder on the 27" Lamont refractor. The transit circle can still be seen in the Detroit Observatory.

During the 1920s a new observatory with two 24 foot diameter copper domes was built on the roof of Angell Hall. The southern dome housed a 10" refractor built by Warner and Swasey. The northern dome had a 15" Cassegrain reflector. Both were on equatorial mounts. These instruments were removed in the fall of 1993 during a complete renovation of Angell Hall.

## **Appendix 5: Telescope Description**

The current telescope was manufactured by DFM Engineering of Longmont, CO., and installed on Angell Hall in December, 1994. It is a 0.4-m diameter F/8 reflecting telescope with full Ritchey-Chretien optics (including field corrector). The reflecting optics are of low expansion material. The telescope has a demonstrated pointing accuracy of better than 30" rms and is completely computer controlled. The 18' Ash Dome is controlled by the handpaddle.

## **Appendix 6: Comparison with other Michigan Telescopes**

University of Michigan astronomers have access to four other telescopes at observatories in Arizona and Chile. Here are the principal differences from the 0.4-m in how these other telescopes are controlled:

### **Hiltner 2.4-m telescope at MDM, Arizona**

The 0.4-m is very much a smaller version of the 2.4-m at Michigan-DartmouthMIT Observatory. Everything is under computer control, and one never sees the telescope while one is observing, as the observer sits in a comfortable control room. The TCS display is different than that of the 0.4-m, but all the same information is presented on the display.

### **McGraw-Hill 1.3-m telescope at MDM, Arizona**

With this telescope, one does most of the observing from the control room. However, to slew the telescope to a new object, one must go out into the dome and press the appropriate direction buttons to drive the telescope to a new position.

### **Curtis Schmidt telescope at Cerro Tololo, Chile**

There is no TCS system for this telescope. All motion of the telescope and dome is by hand. One pushes some buttons to release the brakes on the telescope, and then physically moves the telescope around the sky while one is watching the pointers on the setting circles. The dome is also controlled from a handpaddle in the dome. The CCD camera is controlled, however, from an observing room underneath the telescope. Thus one has quite a bit of exercise going up and down the stairs during the night. What fun!

### **Magellan 6.5-m telescopes, Las Campanas, Chile**

These twin telescopes are completely computer controlled on alt-az mounts. The operator will move the telescope, make sure it is tracking and guiding, and keep the optics aligned. You (the observer) will provide him or her with a list of the objects to be observed during the night. The observer controls the CCD camera and filters, but will not control the telescope.

## Appendix 7: Technical Information for the 0.4-m

### Location

Latitude N 42d 16' 37.8"

Longitude W 83d 44' 23.88"

### Optical Characteristics

Both primary and secondary mirrors are of Corning ULE. The field corrector is a two element design and is not currently installed since we don't do any wide field observations.

The following information was provided by the manufacturer

Primary	
primary mirror diameter	406.4 mm
hole diameter	127.0 mm
radius	2438.4 mm
focal length	1219.2 mm
conic constant	-1.1245
primary f ratio	F/3
Secondary	
secondary mirror diameter	152.4 mm
radius	1197.1 mm
focal length	-598.4 mm
conic constant	-6.502
outside diameter of secondary baffle	202.4 mm
primary-secondary separation	836.5 mm
System	
system f ratio	F/8
focal length	3251.2 mm
plate scale	63.4 "/mm
unvignetted field diameter	75 mm 1.32 deg
back focal distance	84.2 mm

### Pointing Limits

The telescope has a first software pointing limit of 75 degrees zenith distance, with a maximum allowable zenith distance of 80 degrees. The telescope will slew to 75 degrees, but within the range of 75 to 80 degrees zenith distance only set and guide motions are permitted. The limits are roughly  $+47^\circ$  to  $-32^\circ$  in dec and the sidereal time  $\pm 5$ h in RA.

The telescope is protected from going too far by means of a mercury limit switch. If this switch is tripped at an extreme zenith distance, all power to the telescope is turned off and the green light on the control panel will be off. To recover from this, push the HALT MOTORS switch in, and gently push the telescope by hand towards the zenith until the green light comes on. Release the HALT MOTORS switch, and check the coordinates by finding a bright star.

## Eyepieces

The following eyepieces are available

focal length	Magnification	field of view	focus with diagonal	focus w/o diagonal
35mm	91x	32'	1863	765
25mm	128x	24'	1751	653
15mm	213x	15'	1756	658
7.5mm	427x	7'	1748	650

The focus readings were noted at a temperature of 75 degrees F. At cooler temperatures the focus should be at lower numbers. **NUMBERS MAY NOT BE VERY ACCURATE**

The eyepieces are stored in a black plastic storage container kept in the dome. If not there, check in the locked storage cabinet downstairs, or in one of the lockers in the dome. Please report misplaced eyepieces.

## Appendix 8: Filters

All eyepieces are 1.25" diameter and screw onto the base of the eyepiece.

There is a lunar filter in each eyepiece case that has a 13% transmission. Additional filters are kept in boxes in the cabinet in the control room. Please make sure filters go back into the correct box so others can find them:

Set	Filter # and Color	Uses	% transmission, Notes
Basic set	#80A Blue #58 Green  #25 Red #15 Yellow	Great Red Spot, bands Martian polar caps and clouds, red features on Jupiter. Mars, blue Jupiter & Saturn clouds Moon	Worth using Best martian detail
Expansion set	#21 orange #47 violet #11 yellow-green #82 light blue	Jovian bands Venus, Martian polar caps Blue and red features on Jovian planets Jupiter's atmosphere	Worth using Very dark  Almost useless
Advanced set	#8 light yellow  #23A light red  #38A Deep Blue #56 light green	Low contrast dust and ice details (atmospheres, comet dust tails) Enhances contrast for daylight/twilight planets Very bright objects Moon, Jovian & Venusian atmospheres, Martian ice caps	83%  25% excellent for Mercury 17% 53% worth using
Filters in labs rooms	Skyglow Nebula/ ultrablock	Both reduce the glare from light pollution	Light pollution too bad for these to fix...

## Appendix 9: Technical Information for the C8s

The following information was provided by the manufacturer

Primary mirror diameter	8"
System focal length	80" = 2032 mm
Secondary obstruction	2.75"
F ratio	f/10
Near focus	25'
Weight	23 lbs
Theoretical faintest magnitude	14.4
Theoretical resolution	0.5 arcsec

## Appendix 10: The Messier Objects and their coordinates

Epoch 2000. Objects are also in the library (see page 16)

No	Name	m	Dist (kly)	Type	RA hh:mm.m	Dec dd:mm
1	Crab nebula	8.4	6.3	SN remnant	05 : 34:30.3	+22 : 01
2		6.5	37.5	Globular cluster	21 : 33:26.9	-00 : 49
3		6.2	33.9	Globular cluster	13 : 42:10.4	+28 : 23
4		5.6	7.2	Globular cluster	16 : 23:36.0	-26 : 32
5	Butterfly cluster	5.6	24.5	Globular cluster	15 : 18:34.1	+02 : 05
6		4.2	1.6	Open cluster	17 : 40:35.9	-32 : 13
7		3.3	0.8	Open cluster	17 : 53:18.2	-34 : 49
8		6.0	5.2	Diffuse nebula	18 : 04:04.6	-24 : 23
9	Wild duck cluster	7.7	25.8	Globular cluster	17 : 19:15.9	-18 : 31
10		6.6	14.3	Globular cluster	16 : 57:09.3	-04 : 06
11		6.3	6	Open cluster	18 : 51:03.2	-06 : 16
12		6.7	16	Globular cluster	16 : 47:14.3	-01 : 57
13	Hercules	5.8	25.1	Globular cluster	16 : 41:40.4	+36 : 28
14		7.6	30.3	Globular cluster	17 : 37:36.2	-03 : 15
15		6.2	33.6	Globular cluster	21 : 29:57.9	+12 : 10
16		6.4	7	Open cluster	18 : 18:54.4	-13 : 47
17	Omega, swan, horseshoe or lobster	6	5	Diffuse nebula	18 : 20:47.8	-16 : 11
18		7.5	4.9	Open cluster	18 : 20:05.6	-17 : 08
19	Trifid	6.8	28	Globular cluster	17 : 02:37.5	-26 : 16
20		9	5.2	Diffuse nebula	18 : 02:24.1	-23 : 02
21	Delle Caustiche	6.5	4.25	Open cluster	18 : 04:11.6	-22 : 30
22		5.1	10.4	Globular cluster	18 : 36:20.9	-23 : 54
23		6.9	2.15	Open cluster	17 : 56:58.2	-19 : 01
24		4.6	10	Patch in Milky Way	18 : 15:49.0	-18 : 29
25	Dumbell	6.5	2	Open cluster	18 : 31:46.3	-19 : 15
26		8	5	Open cluster	18 : 45:15.9	-09 : 24
27		7.4	1.25	Planetary Nebula	19 : 59:34.6	+22 : 43
28		6.8	18.3	Globular cluster	18 : 24:31.6	-24 : 52
29	Andromeda Galaxy	7.1	4	Open cluster	20 : 24:08.1	+38 : 32
30		7.2	26.1	Globular cluster	21 : 40:23.0	-23 : 11
31		3.4	2900	Sb galaxy	00 : 42:57.4	+41 : 16
32		8.1	2900	E2 galaxy	00 : 42:42.0	+40 : 52
33	Triangulum galaxy	5.7	3000	Sc galaxy	01 : 33:47.2	+30 : 39
34		5.5	1.4	Open cluster	02 : 42:13.5	+42 : 47
35		5.3	2.8	Open cluster	06 : 09:06.6	+24 : 20
36		6.3	5.1	Open cluster	05 : 36:26.2	+34 : 08
37	Winnecke 4	6.2	4.4	Open cluster	05 : 52:16.7	+32 : 33
38		7.4	4.2	Open cluster	05 : 28:45.7	+35 : 50
39		4.6	.825	Open cluster	21 : 31:42.0	+48 : 26
40		8.4	.51	Double Star	12 : 22:16.4	+58 : 05
41		4.6	2.3	Open cluster	06 : 46:13.7	-20 : 44

42	Orion nebula	4.0	1.6	Diffuse nebula	05 : 35:08.5	-05 : 27
43	De Mairan's Nebula	9.0	1.6	Diffuse nebula	05 : 35:30.7	-05 : 16
44	Beehive Cluster, Praesepe	3.7	.577	Open cluster	08 : 40:08.5	+19 : 59
45	Pleiades	1.6	.38	Open cluster	03 : 46:48.4	+24 : 07
46		6.0	5.4	Open cluster	07 : 41:42.1	-14 : 49
47		5.2	1.6	Open cluster	07 : 36:38.8	-14 : 30
48		5.5	1.5	Open cluster	08 : 13:48.5	-05 : 48
49	Whirlpool Galaxy	8.4	60000	E4 galaxy	12 : 29:45.6	+08 : 00
50		6.3	3	Open cluster	07 : 02:44.0	-08 : 20
51		8.4	37000	Sc galaxy	13 : 29:52.7	+47 : 12
52		7.3	5	Open cluster	23 : 24:41.2	+61 : 35
53		7.6	58	Globular cluster	13 : 12:54.1	+18 : 10
54		7.6	87.4	Globular cluster	18 : 55:14.7	-30 : 29
55		6.3	17.3	Globular cluster	19 : 40:00.0	-30 : 58
56		8.3	32.9	Globular cluster	19 : 16:37.6	+30 : 11
57	Ring Nebula	8.8	2.3	Planetary nebula	18 : 53:35.0	+33 : 02
58		9.7	60000	Sbc galaxy	12 : 37:43.7	+11 : 49
59		9.6	60000	E5 galaxy	12 : 42:01.9	+11 : 39
60		8.8	60000	E2 galaxy	12 : 43:37.8	+11 : 33
61	Sunflower galaxy Black eye galaxy	9.7	60000	SABbc galaxy	12 : 21:54.4	+04 : 28
62		6.5	22.5	Globular cluster	17 : 01:11.8	-30 : 07
63		8.6	37000	Sb galaxy	13 : 15:52.8	+42 : 02
64		8.5	19000	Sb galaxy	12 : 56:42.8	+21 : 41
65		9.3	35000	Sa galaxy	11 : 18:57.3	+13 : 05
66		8.9	35000	Sb galaxy	11 : 20:14.3	+12 : 59
67		6.1	2.7	Open cluster	08 : 50:22.3	+11 : 49
68		7.8	33.3	Globular cluster	12 : 39:28.6	-26 : 45
69		7.6	29.7	Globular cluster	18 : 31:23.1	-32 : 21
70		7.9	29.3	Globular cluster	18 : 43:15.1	-32 : 18
71		8.2	13	Globular cluster	19 : 53:47.7	+18 : 47
72		9.3	55.4	Globular cluster	20 : 53:37.8	-12 : 32
73	Little Dumbell	9	2	Asterism	20 : 58:56.3	-12 : 38
74		9.4	35000	Sc galaxy	01 : 36:42.6	+15 : 47
75		8.5	67.5	Globular cluster	20 : 06:05.4	-21 : 55
76		10.1	3.4	Planetary nebula	01 : 42:18.4	+51 : 34
77	Cetus A	8.9	60000	Sb galaxy	02 : 42:39.7	-00 : 01
78		8.3	1.6	Diffuse nebula	05 : 46:41.9	+00 : 03
79		7.7	42.1	Globular cluster	05 : 24:08.3	-24 : 33
80		7.3	32.6	Globular cluster	16 : 17:02.5	- 22 : 59
81	Bode's galaxy	6.9	12000	Sb galaxy	09 : 55:27	+69 : 04
82	Cigar galaxy	8.4	12000	IrrII galaxy	09 : 55:51.8	+69 : 41
83	Southern pinwheel	7.6	15000	SABc galaxy	13 : 37:59.5	-29 : 52
84		9.1	60000	S0 galaxy	12 : 25:07.8	+12 : 53
85	Virgo A	9.1	60000	S0 galaxy	12 : 25:25.1	+18 : 11
86		8.9	60000	S0 galaxy	12 : 26:11.4	+12 : 57
87		8.6	60000	E1 galaxy	12 : 30:32.0	+12 : 24
88		9.6	60000	Sc galaxy	12 : 32:00.0	+14 : 25
89		9.8	60000	E0 galaxy	12 : 35:40.5	+12 : 33
90		9.5	60000	Sb galaxy	12 : 36:50.0	+13 : 10
91		10.2	60000	SBb galaxy	12 : 35:26.6	+14 : 30
92		6.4	26.7	Globular cluster	17 : 17:06.7	+43 : 08
93		6	3.6	Open cluster	07 : 44:38.8	-23 : 52
94		8.2	14500	Sb galaxy	12 : 50:53.8	+41 : 07
95		9.7	38000	SBb galaxy	10 : 44:58.3	+11 : 42
96		9.2	38000	Sa galaxy	10 : 46:45.4	+11 : 49
97	Owl nebula	9.9	2.6	Planetary nebula	11 : 14:48.0	+55 : 01
98		10.1	60000	Sb galaxy	12 : 13:47.7	+14 : 54
99		9.9	60000	Sc galaxy	12 : 18:48.9	+14 : 25
100		9.3	60000	Sc galaxy	12 : 22:55.1	+15 : 49
101	Pinwheel galaxy	7.9	27000	Sc galaxy	14 : 03:11.8	+54 : 21

102	*? Repeat of 101?	10.5	12264	Spiral galaxy	15:06:29.0	+55 : 45
103		7.4	8.5	Open cluster	01 : 33:27.9	+60 : 42
104	Sombrero galaxy	8.0	50000	Sa galaxy	12 : 39:59.2	-11 : 37
105		9.3	38000	E1 galaxy	10 : 47:49.8	+12 : 35
106		8.4	25000	Sb galaxy	12 : 18:57.6	+47 : 18
107		7.9	20.9	Globular Cluster	16 : 32:32.0	-13 : 03
108		10	45000	Sc galaxy	11 : 11:32.0	+55 : 40
109		9.8	55000	Sbc galaxy	11 : 57:36.3	+53 : 23
110		8.5	2900	E6 galaxy	00 : 40:22.2	+41 : 41

## Appendix 11: Operator's Exam

Before you can officially become a telescope operator and bring people up to the observatory, you must pass an operator's exam. During the exam, you will be asked to set up the 0.4-m for observing and shut it down again. You will also have to solve a couple of the following problems:

1. What to do if the power goes out while you have a class in the dome.
2. The dome won't rotate. Diagnose why and what to do.
3. The dome upper shutter won't close. Diagnose why and what to do.
4. The dome lower shutter won't close. Diagnose why and what to do.
5. The telescope isn't tracking. Diagnose why and what to do.
6. The telescope won't slew to the next object: diagnose why it won't move and how to fix it.
7. The telescope ran into the software limits. How do you know which limits and how do you get it out?
8. The telescope ran into the hardware limits. How do you know which limits and how do you get it out?
9. The PC won't send coordinates to the tcs. How do you operate the telescope?
10. There is nothing visible in the eyepiece. What do you do?
11. The target is not in the eyepiece, though it was a few minutes ago. What happened and how do you fix it?

In addition, (and depending on what you do in the observatory) you may be asked to set up a C8 for nighttime or solar observing and put it away again, or set up and take an image with the CCD camera.

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## Reporting Trouble

There are 3 ways to report trouble:

Use the online Angell Hall Observatory Trouble Report Form at <http://www.astro.lsa.umich.edu/undergrad/AHObs.php> (this should be the homepage for all browsers on the control room PC). You will only have access to this form if your computer is in the university domain (so you might not be able to report a problem from home)

Send email to [astro-labs@umich.edu](mailto:astro-labs@umich.edu) (you must use your `uniquename@umich.edu` email to use this system)

Call one of the numbers on the phone list on the bulletin board in the control room. Home numbers are listed for emergencies (e.g. the telescope has stopped responding and you can't figure out why)

You should not leave until you have spoken to somebody if:

- You cannot get the dome closed

- You cannot get the telescope upright

- You had to call 911 (unless you have to evacuate the building, accompany someone to the hospital, etc. Please contact someone ASAP though. We don't want to find out about an accident from the evening news!)