NMSU 1m User's Manual

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Chapter 1

Introduction

The NMSU 1m is an alt-az Ritchey-Chretien telescope located at the Apache Point Observatory. It was constructed by the AutoScope corporation, although the company went out of business before they really completed the project.

The 1m dome is the small dome located closest to the 3.5m dome. The 1m control room is in the main APO building. If you are observing at APO, you will get a key from the observatory staff. The same key should fit the main building, your dorm room, and the 1m dome.

1.1 Computers

In the control room, there is currently one computer: loki, a 400 Mhz Pentium PC, which runs the Linux operating system.

- loki is the main computer used for operating the 1m.

  A wide variety of software, including IRAF, xvista, TeX/LaTeX, etc. is available.

On loki, users should use the observe account; for the current password, check with Jon Holtzman or Dave Summers.

On loki, start up the X window systems after login by typing:

```
startx
```

If observing remotely, you should run things from the remote machine (at NMSU). Only particular users from particular machines will be authorized to use the remote interface; Jon can perform this authorization. Right now, remote users must connect from one of the Linux machines in the department (although you are free to remotely log onto one of these machines from any other machine in the department). Remote logins to loki (and uhuru) can only be done using slogin and the RSA authentication method and are generally not allowed (or needed).

In the dome, there are two racks which hold all of the telescope and CCD control hardware. The left rack holds the main power switches for the telescope/dome, and also the CCD controller and the PC which operates the science CCD. The right rack holds two PCs which control the telescope and the guide camera. The three PCs are:

- PC which handles telescope and dome control, which is called the TOCC computer. IP name (address) is tocc.apo.nmsu.edu (192.41.211.25). This is a Pentium 200 MHz PC.
- PC for the science CCD, which is called nmsucam1 or the Princeton Instruments(PI) computer. This is a Dell 486. It runs a program called winview, which was written by Princeton Instruments and which runs under Windows 3.1. IP name (address) is nmsucam1.apo.nmsu.edu (192.41.211.19).
- PC for the SpectraSource (guider) CCD, which is called the SPEC computer (or alternatively, mc1m, or the MC). IP name (address) is pic1m.apo.nmsu.edu (192.41.211.22). This is a Pentium 200 MHz PC.

All three computers have a common monitor and keyboard. You can switch between which computer is being talked to with the 3 position toggle switch above the keyboard in the right rack. In normal operation, you don't need to type anything from the dome keyboard at all, although it may be advisable to do the telescope initialization which outside in the dome. To do this requires some minimal input to the TOCC computer, so it is recommended to leave the toggle switch in the TOCC position. Toggling this switch to the PI position occasionally causes that computer to hang up, so don't switch the switch without any reason.

In addition, there is another PC in the dome, uhuru, which runs Linux. This computer controls a video camera which can be used during remote operation to confirm the health of the telescope (in particular, the rotator).

1.2 Emergency telescope control

At the current time, the only emergency stop button in the dome is the button which controls the power switch at the top of the left power rack. **Please identify the location of this button before ever using the telescope.** Hitting this button will kill power to the telescope and dome motors and should immediately stop the telescope and dome. This should be done if there is ever any question about whether the telescope is moving safely, or is about to run into something or someone. In the near future, we hope to reinstate the red panic buttons. At the current time, if the situation requires that you hit the emergency stop button, *you must call Dave or Jon before restoring power and using the telescope*; after hitting the stop button, the telescope will be lost and not be aware of the fact that it is lost, which can be a very dangerous situation. Hopefully, you will never need to hit this button.

Emergency stop is also available through computer control using the power program which is automatically started when the telescope control suite (tcomm) is started.

1.3 WARNING about manual telescope motion

Although it is possible to move the telescope manually, this should **never** be done. Always move the telescope using computer control, unless instructed otherwise by Dave or Jon. The reason for this is that it is possible with an alt-az telescope to have cable wrap-up problems, which can be avoided only if the software accurately can keep track of where the telescope is. If the telescope is moved manually, the software won't know about it, and it may then command moves which will cause trouble. This is especially true for the rotator, which has no limit switches at all, and consequently its state of wrap is monitored by software only.

Chapter 2

Starting up

You should get the telescope started and initialized well before it gets dark, to make sure everything is working well. Everything can be initialized without opening the dome and mirror covers. You should probably wait to open the dome and mirror covers until roughly an hour before twilight, just to make sure that bad weather doesn't surprise you.

2.1 Power to the telescope

All power to the telescope components is done using software control through a device called the MasterSwitch. This device allows network control of eight outlets in the dome, into which various components are plugged in. Power switches in the dome should not be used except in the case of an emergency.

2.2 Starting up the software

Everything for the 1m can be done from inside the control room (or remotely from NMSU!). The telescope is run from the Linux PC, loki.

When you start the telescope control programs, a variety of windows will be opened. For nice organization, we recommend that you start the telescope control from an xterm which is located in the lower left of your display.

Start the suite of telescope control programs by entering

```
tcomm
```

in the xterm window. As noted above, it may be a good idea to have nothing else running when you are controlling the telescope.

The tcomm command will actually start eight(!) different progams running - a network aliveness program, a remote video program, a power control program, and four others which will run in new xterms which will automatically be opened, and one (the main command program will run in the window where you typed tcomm). The programs are:

- command : main command window from which ALL commands should be entered.
- telescope control (port) : lower right, used to communicate with TOCC computer. This progam emulates the TOCC computer display and you can directly type in this program with results which are the same as if you were typing in the dome
- CCD control (ccd) : talks with the PI computer to control the science CCD
- SPEC control (gccd) : talks with the SPEC computer to control the guider CCD
- status : upper right, reports telescope and CCD status information to user
- power : upper panel of screen, shows power status and can be used to emergency stop the telescope, and toggle individual powers (which should not be necessary, as these can also be controlled through the command window).
- rvideo : remote video, for use during telescope initialization to watch the telescope
- alive : network aliveness program, sends a signal every 30 seconds from local computer to APO; if telescope control program doesn't see this signal for 5 consecutive minutes, the dome is closed and tracking turned off

In the future, the port, ccd, and spec programs may come up in an iconified state, as they are really only necessary for engineering work - you should not need to ever type anything in these windows.

When you start tcomm, the command program will automatically check to see whether various devices (telescope control program, telescope and dome motors, science CCD, and guider CCD) are powered up and responding. If they are, the program will proceed without requesting any input. If not, the program will ask if you wish to power various devices up.

Once the powers are checked, you will be prompted to initialize the telescope if it has not already been initialized - see below for more details on this. After this, you will get a Command: prompt and the program is ready to accept normal commands.

To quit from the program, you enter the QU command. When this is entered, the program will ask you if you wish to quit the telescope control program running in the dome. If you are done for the night, you should answer yes to this question; however, the telescope will need to be reinitialized after quitting the program in the dome. If you do not quit the dome program, then restarting tcomm will allow immediate operation of the telescope. After this question, the program will ask if you wish to kill power to **everything** in the dome; if you have quit the telescope control program in the dome, you can answer yes to this if you are really done.

It is very important, however, that you do not kill the power to the telescope control program in the dome without exiting it gracefully. Note that the telescope control program which runs in the dome needs to be exited gracefully (i.e., commanded to exit) because the program writes out the current rotator position which is essential to record to prevent cable wrapups. This is so important that the software has a built-in feature which makes a record of when the program is exited. If the program is not exited gracefully, the next startup will REQUIRE THE ENTRY of a password FROM THE DOME before proceeding further. If you get in this mode, you MUST call Dave or Jon - note this is true even if you happen to know the password! Because of this, make sure NOT to turn off the power via the network power switch without gracefully exiting the telescope control software first - if you do, you won't be able to get it started again!

2.3 Initializing the telescope

When the computers are powered up, the telescope and CCD programs go through some initialization commands. For the CCDs, no user input is required - you will see a series of commands come up automatically in the CCD control windows. For the telescope, some interaction is required which needs user input either from the command window or from the TOCC computer in the dome. During initialization it is important to watch the rotator to make sure that cables do not wrap - as a result, initialization should either be done in the dome, or, if operating remotely, using a video camera view of the rotator.

After the TOCC computer is booted up, you will see on the screen (both in the dome and in the telescope control window) the following question:

> Do you wish to initialize the telescope with a :
> I: normal init (uses stored coords to find home positions - will be very
> slow if stored coords are wrong)
> F: full init - finds home positions without any previous knowledge
> Q: very quick init (stored coords - assumes telescope hasn't been moved!)
> S: skip initialization
> Enter your choice:

If you will be initializing from the dome, enter S. In the dome, enter HO (for HOME telescope) at the command prompt to start initialization. This will take approximately 5 minutes. The telescope will move first in azimuth, then in altitude, and finally in the rotator, until it finds its home switches. This is a good time to look at how the telescope moves and to confirm that no cables appear to be under high tension. In particular, you should watch the rotator closely. If it appears that the cables leading to the rotator are wrapping, hit the emergency stop button (on upper part of left panel in dome), or, if running

remotely, by clicking the mouse in the red Emergency Stop section of the power program at the top of the screen. If this happens, you should check with Dave or Jon before restarting anything.

You will not be able to move the telescope until it is initialized.

Next the program will ask:

> Do you wish to initialize the dome (Y or N)?

Enter Y. The dome will spin around until it finds its home sensor. Very rarely, this fails; if it fails, the countdown on the screen will expire without the home position being found. If it fails, this is not a disaster as you can command a dome initialization from the command prompt later on with the DI command - you will need to remember to do this!

Next the program will ask:

> Do you wish to slave the dome (Y or N)?

Enter Y. When the dome is slaved, it should automatically rotate so that the slit is oriented in front of wherever the telescope is pointed.

Note that these initialization questions do not allow you to expose the telescope to the elements, i.e., opening the dome or the louvers. The louvers allow significant airflow through the dome. They should be opened to assure optimal image quality *if it is not too windy.* If it is windy, then image quality may be better with the louvers closed. Obviously, opening either the dome or the louvers exposes the telescope to the elements, so they should only be opened after ensuring that weather conditions do not threaten the health and safety of the telescope! The dome and louvers can be opened/closed later from the command prompt using the OD/CD (open/close dome) and OL/CL (open/close louver) commands.

A list of available commands can be viewed at any time using the HP (Help) command.

2.4 Weather and telescope safety

You are fully responsible for the safety of the telescope in terms of its exposure to weather. You should **not** open the dome or the louvers if there is any chance that weather will damage any of the contents in the dome.

The easiest way to insure this is to follow to the letter the decisions of the 3.5m telescope operator. You should check in with the 3.5m operator at the beginning of the night and get informed about the weather status. It is important that you must consider not only clouds and the possibility of rain, but also the humidity and the dust conditions.

You should monitor the APO 10-micron all sky image

http://www.astro.washington.edu/deutsch/apoinfo/cloudscan/latestimage.html

and also the APO weather page

http://www.astro.washington.edu/deutsch/apo/weather/latestweather.html

closely.

2.5 Preparing to observe

If the weather is good, you should open the dome roughly an hour before twilight. If in any doubt about whether the conditions are good enough to open, consult the 3.5m telescope operator - if the 3.5m is closed, you should be too. This goes for staying open during the night as well. Since you will be depending on the measurements made at the 3.5m to determine whether you should have the dome open, be sure to check in with the 3.5m operator at the beginning of the night and tell them that you will be observing on the 1m and that you would appreciate it if they would tell you if they are closing the 3.5m for a weather condition. If they tell you if they are closing, you should close too!

You can open the dome with the OD command (CD to close the dome). When the dome is opened/closed, the mirror covers should be closed to prevent anything from inadvertently falling on the primary. If these are open, the program will ask whether you want to close them before doing the dome - answer Y.

Next you should open the mirror covers, using OM (CM to close them).

2.6 Controlling the CCD temperature

If the Princeton Instruments CCD is being used, it needs to be cooled using liquid nitrogen. If the Apogee CCD is used, it is cooled thermoelectrically.

2.6.1 Apogee CCD -setting the temperature

The thermoelectic cooler can cool the chip to about 50 degrees C below the ambient temperature in the dome. The dark current is a strong function of temperature, so it is desirable to operate as cold as possible. During the summer, you may not be able to get the CCD colder than -30 to -35 C, while during the winter, you might get to -50 or -55 C. If you will be doing dark current subtraction, you will want to get both science and dark frames at the same temperature. Unfortunately since the ambient temperature changes throughout the night, you may not be able to reach the coldest temperatures at the beginning of the night, and you will have to decide whether you want to change the temperature in the middle of your observing.

2.6.2 Princeton Instruments CCD - filling the dewar

The dewar for the science CCD needs to be filled with LN2 to keep the chip cold. We have a remotely operable filling system which can be commanded to

fill the dewar. This can be done by simply typing FILL. The FILL command will rotate the rotator until the fill opening is pointing to the side, open the valve from the filling dewar, and then suspend for between 5 and 20 minutes (exact time depends on time since last fill). The valve will close automatically when the dewar is filled.

The current hold time for the dewar is approximately 8 hours. It takes about 1.5 hours to cool the chip down completely if it starts out at room temperature. So you must fill the dewar several hours before twilight. To avoid having to fill the dewar during the night, we recommend a fill something during mid-afternoon, then an additional topping off of the dewar just before twilight.

After the FILL is complete, the telescope will move back to the position it was at before the FILL command was issued, and tracking will resume at this position. Note, however, that this is basically a full slew, and the the exact previous pointing will **not** be recovered.

WARNING: the software assumes that you are resuming observing after a FILL, so tracking is turned on; even if you have just done a FILL immediately after initializing the telescope, tracking will start!

2.7 Summary of startup procedure

1. Start up the software in the control room from an appropraite directory using the *tcomm* command
2. In the dome (or inside), answer the question about initializing the telescope by requesting a normal initialization if the telescope was last shut down gracefully and the stored coordinates are where the telescope actually is, otherwise use a full initialization.
3. Initialize the dome
4. Fill the dewar (Princeton CCD) or set the temperature (Apogee CCD)
5. Open the dome and mirror covers (in that order) about an hour before twilight, weather permitting.
6. Top the dewar off just before twilight (Princeton CCD).

Chapter 3

Operating the telescope

The telescope can either be operated from the dome or from the control room. Commands are generally identical from either location, but there are a few commands which are only available from the dome, and a few which are only available from the control room.

3.1 The status display

The upper section of the status window gives information about the telescope/dome systems. The left column gives the current RA, DEC, hour angle of the telescope, coordinate epoch, and position angle. The next column gives the azimuth, altitude, rotator, and focus positions for each of the three focus motors. The rightmost column gives the current UT, local sidereal time, airmass, and the focus position in a coordinate system which gives mean focus, xtilt, and ytilt.

Other entries give the dome position and status (initialized/unitialized, slaved/not slaved, open/closed), and mirro cover status (open/closed).

If *any* of the items appear in reverse video, there is likely to be something configured such that you will have significant problems with your observations (e.g., the dome or mirror covers are closed!).

Several of the items are not encoded, so the status only reports where the computer *thinks* the item is, which is not necessarily where it *really* is, although if things are working well, the computer should correctly know where things are. However, if something seems peculiar, it is worth going out and looking at the telescope/dome!

3.2 The command window

All commands should be entered in the command window. For all commands, you will not get a command prompt until the previous command completes.

The software allows you to write simple scripts in an external file which can be read in by the program to issue a series of commands automatically. Input

script files should have commands which are identical to what you would need to type in the command window. To execute a script, you use the command:

INPUT filename

where filename is the name of the file with the commands to execute. Our convention is to use .inp as the extension for script files. A script can call another script, up to 5 layers deep.

3.2.1 Restarting tcomm

If for some reason things appear to hang up (i.e., nothing returns for several minutes after you'd really expect it to, you can restart the tcomm programs after issuing a CTRL-\ in the command window. This should kill all of the windows, and then retyping tcomm should start everything up again. However, if this is necessary, please inform Jon of the circumstances - we would really like to get things working without ANY hangups.

3.3 Moving the telescope

The following commands can be used to move the telescope:

CO [*hh mm ss dd mm ss*]

The CO command will move the telescope to some user-specified coordinates. If you do not specify a position on the command line, the program will prompt for an RA and DEC, and then ask you to confirm the move. The coordinates will be interpreted using the current epoch, which defaults to 1950 (the default epoch can be changed using the NE command which will prompt you for a new epoch).

SA

Move the telescope to an SAO star. The program will ask whether you want an SAO near near the current telescope position (T), near some other specified RA/DEC (O), or some specified ALT/AZ (A). If you choose one of the latter two options, you will be prompted for coordinates. You will then be prompted for an acceptable magnitude range for the SAO star (<CR> to allow any brightness). Note that the on-line SAO catalog only contains stars down to 7th magnitude and does not have fainter catalog members at this time. The program will find the nearest SAO star to your coordinates, and ask if you want to move there; enter Y to move.

RF [*id*]

Move the telescope to the position of star *id* in an open user coordinate file (see section ??). If not specified on the command line, *id* will be prompted for.

QM [$\Delta\alpha\Delta\delta$]

Offset the coordinate by $\Delta\alpha$ arcseconds in right ascension and $\Delta\delta$ arcseconds in declination. If not specified on the command line, the offsets will be prompted for.

OFFSET [$\Delta x\Delta y$]

Offset the coordinate by Δx *pixels* along rows and Δy pixels along columns of the CCD. If not specified on the command line, the offsets will be prompted for. These allow "instrument plane" offsets, i.e., in the coordinate system of the CCD even if the instrument is rotated with N no longer oriented along columns. Unlike the 3.5m, the instrument plane offsets are specified in pixels, not arcseconds.

CENTER

Move the telescope such that a marked image on the CCD frame will be moved to the center of the CCD frame. This requires that an image has already been obtained. If you use this command, you will be prompted to mark the location of an object in the CCD frame; use C to centroid on the position of the mouse, or I to just take the integer pixel location of the mouse.

LOCATE

Move the telescope such that a marked image on the CCD frame will be moved to any another desired location. Again, this requires that an image has already been obtained. If you use this command, you will be prompted to mark the location of an object in the CCD frame, then prompted to mark a second position to which the object will be moved. Mark these positions using C to centroid at the location of the mouse, or I to use the integer pixel location of the mouse.

PA

Change the position angle to the specified PA. The position angle is measured from north to vertical on the chip when the image is displayed in sky orientation (for the PI CCD, this is (1,1) in the upper left).

HO

Reinitialize the telescope with a full initialization.

IN

Reinitialize the telescope with a normal initialization.

INIT

Go through startup sequence that is run when starting tcomm, i.e. telescope initialization, dome initialization, and louver query.

3.4 Coordinate epoch command

The default coordinate epoch on startup in 1950. The default epoch for coordinate entry can be changed using:

NE

Change the input epoch to a new value. The program will give the current epoch, and prompt for a new value. Note that the epoch on the display will not change until you move to an object using the new epoch.

3.5 User catalogs

Users can create catalogs of object positions which can be referenced by an ID number to maximize efficiency and minimize input error during the night. The format of the user catalogs is identical to that used by REMARK on the 3.5m. Each object should be put on a separate line with the following format:

object name <TAB> RA (hh:mm:ss) <TAB> DEC (dd:mm:ss) <TAB> epoch <TAB> (proper motion in RA) <TAB>(proper motion in DEC)

The following commands can then be used with these files:

OF

Open a new input file. The file name will be prompted for.

RF [*id*]

Move to object *id*. If no *id* is given, it will be prompted for

3.6 Focus commands

The telescope can be focussed by moving the position of the secondary. The secondary position is controlled by three separate motors, so the mirror can be tilted as well as pistoned. Tilting the mirrors changes the collimation and thus is not a motion which is allowed to normal users.

Note that the focus is a function of temperature, since the telescope structure expands/contracts as a function of temperature. A *rough* guess of the approximate focus can be found from the expression:

$$focus = -12580 - 18\text{auxtmep}$$

where auxtemp is the auxiliary temperature measured at the side of the mirror cell that can be determined by using the WE command and looking at the output in the telescope control window.

The focus commands are:

FOCRUN

Take a series of exposures at different focus values. You will be prompted for a starting focus value, a delta focus (amount to change focus between each exposure), a number of exposures, and an exposure time. After entering these, the program will automatically take the requested number of exposures. The program will always approach a given focus value from the same direction, *assuming you specify a positive delta focus value*. When using FOCRUN, the CCD will automatically switch into a "fast" readout mode (which still isn't that fast!) which has increased readout noise; when done, the CCD will be switched back into the normal readout mode.

FO f

Move the focus to position f. This command will automatically approach the desired position from the same direction.

DF Δf

Moves the focus by a relative amount, Δf. If not specified on the command line, the amount to move will be prompted for

XTILT *tilt* (ENGINEERING)

YTILT *tilt* (ENGINEERING)

Tilt the secondary mirror to the specified angle.

Chapter 4

Using the science CCD

4.1 The instrument

The main science instrument is the Princeton Instruments 1024× 1024 CCD. This device has 24μ pixels, given a scale of approximately $0.81''$/pixel.

4.2 The status display

4.3 The image display window

The first time an image is taken, the program opens an Image Display window on the console, and loads a color map as well as displaying the image. Once an image has been displayed, the Display window will accept interaction asynchronously of commands in the command window, provided that a wait for input, or any other I/O is not pending. To interact with the image, simply move the mouse onto the display window. The current pixel location of the cursor will be displayed in a frame at the base of the image display along with the pixel intensity. The arrow keys are used for find control (one pixel at a time) of the cursor position.

The following mouse buttons and keyboard keys are active while the mouse is located on the image display:

Mouse Buttons

Button	Function
LEFT	ZOOM IN, centered on the cursor
MIDDLE	ZOOM OUT, centered on the cursor
RIGHT	PAN, move the pixel under the cursor to the center

Keyboard Commands

Key	Function
R	RESTORE image to the original zoom/pan
+	BLINK Forwards through the last 4 images.
-	BLINK Backwards through the last 4 images.
P	Find the PEAK pixel near the cursor & jump the cursor there
V	Find the LOWEST pixel ("Valley") near the cursor & jump the cursor there
#	"Power Zoom" zoom at the cursor to the maximum zoom factor
H	Toggle between small and full-screen cross-hairs
]	Clear boxes and stuff off the image display

Color Bar Adjustment:

If you place the mouse on the color bar, these commands are available to adjust the contrast of the image:

LOW CONTRAST	Hold down the LEFT Mouse button, drag the left end of the color bar.
HIGH CONTRAST	Hold down the RIGHT Mouse button, drag the right end of the color bar.
ROLL COLOR MAP	Hold the MIDDLE Mouse button, "roll" the color bar left or right.

The position of the mouse cursor displays the range of intensities represented by that color.

Pressing the R key while the mouse is on the color bar restores the original color map (undoing any change of the contrast or "roll" changes made with the mouse buttons).

4.4 Commands

The following commands are available:

EXP [*time*]

Take an exposure of length *time* seconds.

SETFILT [*name*]

Change the filter wheel to filter *name*. You must supply a name which matches that in the current filter table. For a list of available filters, use SETFILT without any arguments. SETFILT allows you to operate without knowing the details of which filter is located in which slot. In the future, SETFILT will also allow for automatic focus offsets between filters, but this is not yet implemented.

FILTINIT

Initializes the filter wheel if it has gotten lost.

FILENAME [*name*]

Change the default root file name to *name*.

NEWEXT [*ext*]

Change the extension for the next file to be the number *ext*.

FITS

Set filetype for future image stores to be FITS.

-DISK

Turn off autosaving of images. Turn this back on using FITS.

+DISPLAY/-DISPLAY

Turn on/off autodisplay of images after they are taken.

+XFER/-XFER

Turn on/off auto-transfer of images to NMSU after they are taken. Currently, automatic transfer occurs to the subdirectory under /home/1m (on the NMSU Linux machines) corresponding to the observation date.

SCALE *low high*

Redisplay the current image with greyscale scaling between *low* and *high*.

SKYSCALE

Sets mode for autoscaling to have black level somewhat below mean level in image, and white level above it. This is the default.

FULLSCALE

Sets mode for autoscaling of images to be from minimum pixel (black) to maximum pixel (white).

SAMESCALE

Sets scaling for future pixels to be identical to the current scale.

CENTER

Move the telescope so that an object/location marked on the display window will move to the center of the CCD field. You will be prompted to mark the location of an object in the CCD frame; use C to centroid on the position of the mouse, or I to just take the integer pixel location of the mouse.

FLAT *ndesired nmax startexp fudge*

Takes a series of flat fields, adjusting exposures times to maintain good S/N, for use in taking twilight flats. A "good" flat is defined as one with a mean level (over bias) of somewhere between 5000 and 20000 DN, with a minimum exposure time of 1 second. The routine will start out by taking

an exposure of length *startexp*. From this, it will compute a new exposure time which is required to obtain a mean of 10000, after multiplying by the fudge factor *fudge*, which accounts for the changing brightness of the twlight sky (*fudge* should be ~ 1.5 for evening twilight and arounge ~ 0.7 for morning twilight. In no case will the program let the exposure time be longer than 30 seconds, and any 30 second flat will be counted as a "good" flat to prevent a large number of unsuccessful flats being taken when it is too dark. The program will continue taking flats until it gets *ndesired* "good" flats or until it has taken "nmax" flats.

CCDFAST

Princeton Instruments CCD only. Switches the CCD into "fast" readout mode, in which a full exposure takes about 30 seconds instead of a minute, at the price of increased readout noise.

CCDSLOW

Princeton Instruments CCD only. Switches the CCD into "normal" readout mode, in which a full exposure takes about 60 seconds.

SETTEMP *temp Apogee CCD only.* Set the desired CCD temperature (degrees C). Thermoelectric cooler can get to about 50 degrees below ambient. You should avoid requesting a temperature that cannot be reached.

4.5 Standard star observations

Several commands are available to increase your efficiency in observing standard stars. There is a full use catalog of all of the Landolt standards, plus several others, in the top level observe directory, with filename standards.apo. To allow use of this catalog in conjuction with your own catalog of objects, there are separate commands to open and read from the standards file, so you can have both the standards file and a user file open simultaneously. The standards file also includes the UBVRI magnitudes of the stars, and the observing program knows about the throughput of the 1m telescope, so the program is also capable of choosing good exposure times for you, freeing you from having to take the time of choosing exposure times (and making bad choices), and assuring uniform exposure levels of your different standards

The relevant commands are:

OS

Open the standards file (analagous to OF for user files). If you are running in a subdirectory under the top level observe login directory, you will enter: ../standards.apo

RS [*id*]

Move to standard *id*. If no *id* is given, it will be prompted for.

STAN [*filtname*]

Take an exposure of the current standard through filter *filtname*. You must have already moved to the star using the RS command. The program will move the filter automatically and will take an exposure based on the known magnitude of the star and the throughput of the system.

FUDGE [*fudge*]

Sets a fudge factor for the automatic expossure time calculation of the STAN commands. All standard star exposure times will be multiplied by the fudge factor specified.

MAG m1 m2 m3 m4 m5 m6

Do not use this command unless instructed to - defaults should be correct!) Tell the program which magnitude to use for the exposure time calculation for each filter. There are 6 filter slots, so 6 integers must be specified. The possible choices for the magnitude codes are 1, 2, 3, 4, or 5, corresponding to U,B,V,R,or I. So, for example, if UBVRI are loaded in slots 12345, you would use the command MAG 1 2 3 4 5 0. The correct defaults are loaded at startup.

ZERO z1 z2 z3 z4 z5 z6

Do not use this command unless instructed to - defaults should be correct!) Tell the program which zeropoints to use for the exposure time calculation for each filter. There are 6 filter slots, so 6 zeropoints must be specified. The zeropoint gives the magnitude which gives 1 DN/second through the desired filters.

Chapter 5

Using the guider CCD

The current guider CCD is a camera purchased from Spectrasource Inc.; it uses a Kodak 512×512 CCD with 20μ pixels.

In general, you can issue the same commands to the guider CCD as you can to the science CCD. To do so, use the same command names but preceeded by the letter "G", e.g., GEXP t will take a guider exposure of length t seconds.

Since our telescope is a three-axis telescope (alt-az-rot) and a single guide star only contains two positions (x-y), the absolute quality of the guiding depends on an accurate pointing model (although less so than if there were no guider at all!). We use the guider observations to update altitude and azimuth, and assume that the rotator angle is correct. Since the guider is located off axis, errors in the rotator angle will manifest themselves as small arcs of stars in the science camera, centered around the position of the guide camera (which is off of the chip).

To minimize errors from inaccuracies in the pointing model, we recommend that, before starting to guide, you go to an SAO star near your object, take an exposure, do a CENTER command, and then update the telescope coordinates with a UC command before moving to your object and starting to guide.

To start guiding, first take a guider exposure to see if there is an acceptable guide star and to determine a good exposure time. Ideally, you will have a star which has good S/N with an exposure time of less than or approximately equal to 1 second. Once you have a picture taken with a good exposure time, you can start guiding by issuing the GUIDE command. This will take a picture with your exposure time, ask you to mark the guide star in the guide CCD image, and will then start autoguiding on this star.

Guiding will continue until you do a slew with the telescope or unless you issue a GUIDEOFF command.

Other commands relevant to guiding:

GUPDATE n

> Sets the number of guide exposures to average centroids from before sending a position update command to the telescope. Default is 5.

GSIZE *n*

Sets the size of the box used for computing centroids. Default is 11 pixels.

NOSHUTTER

Puts guider in NOSHUTTER mode where exposures are taken without using the shutter. You must remember to issue the OPEN command to open the shutter before starting to guide! Currently, this command must be issued from the guider CCD control window (not the command window).

SHUTTER

Puts guider into normal SHUTTER mode. Currently, this command must be issued from the guider CCD control window (not the command window).

OPEN

Opens the guider shutter. Currently, this command must be issued from the guider CCD control window (not the command window).

CLOSE

Closes the guider shutter. Currently, this command must be issued from the guider CCD control window (not the command window).

WRITE

Toggles mode where each individual guide exposure is saved to disk. Default is *not* to save each image. Currently, this command must be issued from the guider CCD control window (not the command window).

GUIDINIT

Initializes the guider stages by moving them to their home positions. Users should **not** issue this command without being instructed to do so!

Chapter 6

Shutting down

To close the telescope down, you need to move the telescope to its stow position, close the mirror covers and dome, and exit the telescope control program gracefully. *Do not power down the telescope control computer without first exiting the program gracefully - if you do so, you will not be able to start it up again!.* The following commands are used:

CM

Closes the mirror covers. The telescope will automatically move to be pointing nearly vertically, since this reduces stress on the mirror cover motors.

ST

Stows the telescope in the default stow position.

CD

Closes the dome.

QU

Quits the program. When you enter QU from the command window in the control room, the program will ask you if you wish to quit the telescope control program in the dome as well as the remote programs. Generally, you should answer Y to this question; doing so, will require that you restart the dome telescope program (by rebooting the telescope control PC) and reinitialize the telescope. If you will be restarting tcomm soon and do not want to be forced to reinitialize, you can enter N. However, *Do not kill the power to the telescope control computer in the dome until you have gracefully exited the program running there, or else you will not be able to get started again!.* If you enter QU on the TOCC PC in the dome, you can quit the program running in the dome.

Finally, the program will ask if you wish to kill power to everything in the dome. If you have quit the telescope control program in the dome, you can answer Y here; if not, answer no.

Appendix A

Command summary

- ALTAZ — Move the telescope to a specified alt/az position
- CD — **C**lose the **D**ome slit.
- CENTER — move the telescope to **CENTER** on an object in an image based on the current image display.
- CF — **C**lose the command **F**ile.
- CL — **C**lose the **L**ouvers - the large vents at the floor of the dome.
- CLOSE — **CLOSE**s the guide shutter.
- CM — **C**lose the **M**irror covers.
- CO — move the telescope to the **CO**ordinates given as hh mm ss dd mm ss.
- DI — **D**ome **I**nitialization command.
- -DISK — turn off autosaving of images to **DISK**.
- -DISPLAY/+DISPLAY — turn off/on auto **DISPLAY**ing of images.
- DF [Δf] — move focus position by **D**elta **F**ocus = Δf.
- DM — toggle **D**o**M**e tracking on/off.
- EXP [*time*] — take an **EXP**osure of length *time* seconds.
- FILENAME [*name*] — change the default root for image **FILENAME**s to *name*.
- FILL — **FILL** the dewar; this process is automatic now.
- FILTER [n] — switch current **FILTER** to position n.

- FITS — set file type to **FITS** format and turn on autosaving of images.
- FLAT *ndesired nmax startexp fudge* — takes a series of **FLAT** field images; see text for more.
- FO [*f*] — move to **FO**cus position *f*.
- FOCRUN — **FO**cus **RUN**.
- FUDGE — setup for STAN command.
- FULLSCALE — set autoscaling of images to have greyscaling showing **FULLSCALE** of image.
- GCENTER — CENTER command for guider.
- GEXP — EXP command for guider.
- GFLAT — FLAT command for guider.
- GFOCRUN — **FO**cus **RUN** in the **G**uider.
- GFULLSCALE — FULLSCALE command for guider.
- GLOCATE — LOCATE command for guider.
- GOFFSET [$\Delta x\ \Delta y$] — **Offset** the telescope by a specified number of *pixels* in the guider
- GSAMESCALE — SAMESCALE command for guider.
- GSSCALE — SSCALE command for guider.
- GSKYSCALE — SKYSCALE command for guider.
- GUIDE — turn on the **GUIDE** system.
- GUIDEOFF — turn the **GUIDE** system **OFF**; for long exposures, a warning will come up if guiding if off.
- GUPDATE [*n*] — **UPDATE** the number of **G**uide exposures to determine centroid.
- GSIZE [*n*] — set the **SIZE** of box used by **G**uide camera for computing star centroids.
- HO — initialize telescope to **HO**me position.
- HP — **H**el**P** command.
- INPUT filenmae — execute a series of commands from the specified **INPUT** file

- INST — select a new default instrument for pointing (currently, either science CCD or guider CCD.
- LOCATE — move the telescope such that object in current image display is moved to some other specified **LOCATION** in the display.
- MAG — setup for STAN command.
- MEXP [*time number*] — take *number* of **M**ultiple **EXP**osures of length *time* seconds.
- NE — change to a **N**ew **E**poch for coordinates.
- NEWEXT [*ext*] — give a **NEW EXT**ension for the next image file.
- NOSHUTTER — set guide camera to use **NO SHUTTER** during guide exposures.
- OBJECT — specify **OBJECT** name for FITS header.
- OD — **O**pen the **D**ome slit.
- OF — **O**pen the command **F**ile created by user.
- OFFSET [Δx Δy] — **Offset** the telescope by a specified number of *pixels*.
- OM — **O**pen the **M**irror covers.
- OL — **O**pen the **L**ouvers - the large vents at the floor of the dome.
- OPEN — **OPEN** the guide camera shutters.
- OS — **O**pen the **S**tandard star file.
- PA — change the **P**osition **A**ngle of the detector.
- PM — move the telescope to a position of one of the last five **P**revious **M**ove positions.
- QCK [*time*] — take a **Q**ui**CK** exposure of length *time* seconds, **but do not save it**.
- QM [Δ *RA* Δ *DEC*] — do a **Q**uick **M**ove with the offset in RA and DEC in arcsec.
- QU — **QU**it the telescope command program *gracefully*.
- RF [*id*] — **R**ead from command **F**ile created by user and move telescope to object *id*.
- RS — **R**ead from **S**tandard star file.
- SA — set the telescope to point at a **SA**o star.

- SAMESCALE — set autoscaling of images for future images to be the **SAMESCALE** as current image.
- SCALE *low high* — redisplay current image with new grey **SCALE** between *low* and *high*.
- SHUTTER — sets guide CCD camera into normal **SHUTTER** mode.
- SKYSCALE — set autoscaling of images to have grey**SCALE** levels around mean **SKY** level.
- SLEEP [*t*] — suspend operation (sleep) for specified number of seconds.
- STAN [*n*] — take an exposure through filter number *n* of a **STAN**dard star; program determines exp time.
- ST — **ST**ow the telescope to stow position to quit.
- TR — toggle **TR**acking on and off.
- UC – **U**pdate bf Coordinates for current telescope pointing.
- WRITE — toggles to mode where guide exposures are **WRITE**en to disk; default is not to save images.
- ZERO — setup for STAN command.

Appendix B

Standard stars

For user convenience, a master coordinate/standards file with a large number of standard stars is available which can be used with the OS/RS and STAN commands. OS/RS allow ease of pointing to a desired standard, and the STAN command can be used to take an exposure, letting the software calculate a good exposure time based on the standard magnitude and the system throughput through a desired filter.

The master standards file is called standards.apo, and resides in the top level observe directory (/home/loki2/observe/standards.apo). The current version contains 918 entries. Entries 1-223 come from Landolt 1982, 224-250 are dummy entries, 251-280 are standards in M67 from Montgomery, 281-300 are dummy entries, 301-826 are from Landolt 1992 (some of which duplicate entries from Landolt 1982), 827-900 are dummy entries, 901-918 are southern spectrophotometric standards from Landolt 1992a.

An abbreviated list of recommended single star standards is presented below. These stars were chosen to be at a good brightness for the 1m, sample stars around the sky, with care given to include a red and blue star at all right ascensions. Stars marked with an asterisk are especially preffered.

The ID numbers are the numbers by which the star is referred to in the standards.apo file, i.e., you should do a RS id to move to a given star.

	ID	NAME	RA	DEC	Epoch	V	B-V
*	3	BD -15 115	00:37:36.00	-15:04:51.0	1985.0	10.881	-0.190
*	324	SA 92 409	00:55:14.00	+00:56: 7.0	2000.0	10.627	1.138
	4	BD -12 134	00:46:19.00	-11:57:32.0	1985.0	11.775	-0.294
*	311	SA 92 235	00:53:16.00	+00:36:18.0	2000.0	10.595	1.638
	322	SA 92 342	00:55:10.00	+00:43:14.0	2000.0	11.613	0.436
	333	SA 92 263	00:55:40.00	+00:36:18.0	2000.0	11.782	1.048
*	21	HD 12021	01:57:10.00	-02:10:37.0	1985.0	8.874	-0.082
*	356	SA 93 424	01:55:26.00	+00:56:43.0	2000.0	11.620	1.083
	352	F 16	01:54: 8.00	-06:42:54.0	2000.0	12.406	-0.012
*	15	SA 93 326	01:54: 4.00	+00:42:40.0	1985.0	9.569	0.454
*	29	BD -02 524	02:56:54.00	-02:03:26.0	1985.0	10.307	-0.104
*	374	SA 94 251	02:57:46.00	+00:16: 2.0	2000.0	11.204	1.219
	361	F 22	02:30:17.00	+05:15:51.0	2000.0	12.799	-0.054
	375	SA 94 702	02:58:13.00	+01:10:53.0	2000.0	11.594	1.418
	373	SA 94 242	02:57:21.00	+00:18:38.0	2000.0	11.728	0.301
*	381	SA 95 96	03:52:54.00	+00:00:19.0	2000.0	10.010	0.147
	420	SA 95 236	03:56:13.00	+00:08:43.0	2000.0	11.491	0.736
*	415	SA 95 74	03:55:31.00	-00:09:13.0	2000.0	11.531	1.126
*	36	SA 95 52	03:53:28.00	-00:10:58.0	1985.0	9.574	0.529
*	422	SA 96 36	04:51:43.00	-00:10:12.0	2000.0	10.591	0.247
*	426	SA 96 235	04:53:19.00	-00:05: 4.0	2000.0	11.140	1.074
	425	SA 96 83	04:52:59.00	-00:14:44.0	2000.0	11.719	0.179
	423	SA 96 737	04:52:35.00	+00:22:29.0	2000.0	11.716	1.334
*	43	SA 96 393	04:51:44.00	+00:00:39.0	1985.0	9.652	0.598
*	433	SA 97 351	05:57:37.00	+00:13:42.0	2000.0	9.781	0.202
	51	SA 97 346	05:56:41.00	+00:13:17.0	1985.0	9.260	0.594
	429	GD 71	05:52:28.00	+15:53:15.0	2000.0	13.032	-0.249
*	435	SA 97 284	05:58:25.00	+00:05:12.0	2000.0	10.788	1.363
	434	SA 97 75	05:57:55.00	-00:09:29.0	2000.0	11.483	1.872
*	462	SA 98 653	06:52: 5.00	-00:18:19.0	2000.0	9.539	-0.004
*	461	SA 98 193	06:52: 4.00	-00:27:18.0	2000.0	10.030	1.180
	443	SA 98 978	06:51:34.00	-00:11:28.0	2000.0	10.572	0.609
	459	SA 98 185	06:52: 2.00	-00:27:21.0	2000.0	10.536	0.202
	467	SA 98 670	06:52:12.00	-00:19:17.0	2000.0	11.930	1.356
*	498	SA 99 438	07:55:54.00	-00:16:51.0	2000.0	9.398	-0.155
	69	SA 99 367	07:53:26.00	-00:23:13.0	1985.0	11.149	1.005
	73	SA 99 418	07:54:41.00	-00:15: 7.0	1985.0	9.474	-0.041
*	65	BD+05 1668	07:26:36.00	+05:16:16.0	1985.0	9.843	1.557
	72	SA 99 408	07:54:27.00	-00:23: 8.0	1985.0	9.807	0.407

	ID	RA	DEC	Epoch	V	B-V	
*	500	SA 100 241	08:52:35.00	-00:39:48.0	2000.0	10.139	0.157
*	505	SA 100 394	08:53:55.00	-00:32:21.0	2000.0	11.384	1.317
	79	SA 100 606	08:52:12.00	-00:06: 4.0	1985.0	8.641	0.052
	504	SA 100 280	08:53:36.00	-00:36:41.0	2000.0	11.799	0.494
	501	SA 100 162	08:53:15.00	-00:43:29.0	2000.0	9.150	1.276
*	551	SA 101 363	09:58:19.00	-00:25:35.0	2000.0	9.874	0.261
*	536	SA 101 281	09:57: 5.00	-00:31:38.0	2000.0	11.575	0.812
*	511	BD -12 2918	09:31:18.00	-13:29:20.0	2000.0	10.067	1.501
	85	HD 84971	09:47:59.00	-02:38:29.0	1985.0	8.636	-0.159
*	100	SA 102 58	10:54:32.00	-01:20:38.0	1985.0	9.380	0.060
*	562	SA 102 620	10:55: 6.00	-00:48:19.0	2000.0	10.069	1.083
	561	G44 40	10:50:54.00	+06:48:57.0	2000.0	11.675	1.644
	564	SA 102 1081	10:57: 4.00	-00:13:10.0	2000.0	9.903	0.664
	566	G163 50	11:08: 0.00	-05:09:26.0	2000.0	13.059	0.035
*	107	HD 100340	11:32: 3.00	+05:21:40.0	1985.0	10.117	-0.242
*	112	SA 103 526	11:56: 8.00	-00:25:13.0	1985.0	10.903	1.089
*	106	BD+05 2468	11:14:46.00	+05:02:20.0	1985.0	9.348	-0.116
	568	G10 50	11:47:44.00	+00:48:55.0	2000.0	11.153	1.752
	569	SA 103 302	11:56: 6.00	-00:47:54.0	2000.0	9.861	0.368
*	595	SA 104 461	12:43: 7.00	-00:32:21.0	2000.0	9.705	0.476
*	605	SA 104 598	12:45:17.00	-00:16:37.0	2000.0	11.479	1.106
	114	SA 104 337	12:41:42.00	-00:29:21.0	1985.0	11.207	0.768
	615	BD+2 2711	13:42:21.00	+01:30:17.0	2000.0	10.367	-0.166
*	124	SA 105 66	13:38:49.00	-01:08:53.0	1985.0	9.426	0.977
	616	HD 121968	13:58:52.00	-02:55:12.0	2000.0	10.254	-0.186
*	612	SA 105 505	13:35:25.00	-00:23:38.0	2000.0	10.270	1.422
	614	SA 105 815	13:40: 4.00	-00:02:10.0	2000.0	11.453	0.385
	606	G14 55	13:28:22.00	-02:21:28.0	2000.0	11.336	1.491
*	133	SA 106 485	14:43:28.00	-00:33:20.0	1985.0	9.484	0.380
	128	SA 106 834	14:38:43.00	-00:11: 0.0	1985.0	9.088	0.701
*	619	SA 106 700	14:40:52.00	-00:23:36.0	2000.0	9.785	1.362
*	135	SA 107 544	15:36: 3.00	-00:12:14.0	1985.0	9.037	0.401
*	657	SA 107 484	15:40:17.00	-00:21:13.0	2000.0	11.311	1.237
	139	SA 1006 544	15:37:48.00	+00:17:16.0	1985.0	11.715	0.764

	ID	RA	DEC	Epoch	V	B-V	
	145	HD 149382	16:33:36.00	-03:58:59.0	1985.0	8.944	-0.281
	146	SA 108 1332	16:34:35.00	-00:02:18.0	1985.0	9.199	0.384
	149	SA 108 1491	16:36:28.00	-00:00:54.0	1985.0	9.059	0.965
*	673	SA 108 551	16:37:47.00	-00:33: 6.0	2000.0	10.703	0.179
*	671	SA 108 475	16:37: 0.00	-00:34:40.0	2000.0	11.309	1.380
	674	SA 108 1918	16:37:50.00	-00:00:37.0	2000.0	11.384	1.432
*	154	HD 160233	17:37:56.00	+04:21:19.0	1985.0	9.095	-0.054
*	690	SA 109 537	17:45:42.00	-00:21:34.0	2000.0	10.353	0.609
*	682	BD -4 4226	17:05:15.00	-05:05: 5.0	2000.0	10.071	1.415
	688	SA 109 199	17:45: 2.00	-00:29:28.0	2000.0	10.990	1.739
	683	SA 109 71	17:44: 6.00	-00:24:59.0	2000.0	11.493	0.323
*	170	HD 173637	18:45:50.00	-07:56:56.0	1985.0	9.375	0.236
*	727	SA 110 450	18:43:52.00	+00:22:58.0	2000.0	11.585	0.944
*	698	SA 110 340	18:41:29.00	+00:15:22.0	2000.0	10.025	0.303
	730	SA 110 319	18:43:55.00	+00:02: 1.0	2000.0	11.861	1.309
	724	SA 110 441	18:43:34.00	+00:19:40.0	2000.0	11.121	0.555
	703	SA 110 355	18:42:19.00	+00:08:24.0	2000.0	11.944	1.023
*	174	SA 111 2522	19:36:19.00	+00:35:31.0	1985.0	9.706	0.164
	178	SA 111 2009	19:37: 9.00	+00:24:24.0	1985.0	10.608	0.889
*	731	SA 111 775	19:37:16.00	+00:12: 5.0	2000.0	10.744	1.738
	177	SA 111 1969	19:36:58.00	+00:23:44.0	1985.0	10.384	1.961
	733	SA 111 1925	19:37:29.00	+00:25: 1.0	2000.0	12.388	0.395
*	744	SA 112 805	20:42:46.00	+00:16: 8.0	2000.0	12.086	0.152
*	743	SA 112 275	20:42:36.00	+00:07:21.0	2000.0	9.905	1.210
	739	SA 112 595	20:41:18.00	+00:16:28.0	2000.0	11.352	1.601
	741	SA 112 223	20:42:14.00	+00:09: 1.0	2000.0	11.424	0.454
	745	SA 112 822	20:42:55.00	+00:15: 4.0	2000.0	11.549	1.031
*	764	SA 113 466	21:41:28.00	+00:40:14.0	2000.0	10.004	0.454
*	767	SA 113 475	21:41:51.00	+00:39:19.0	2000.0	10.306	1.058
*	194	HD 205556	21:35:11.00	+05:25:11.0	1985.0	8.301	-0.054
	765	SA 113 259	21:41:44.00	+00:17:37.0	2000.0	11.742	1.194
	215	HD 216135	22:49:41.00	-13:23:12.0	1985.0	10.112	-0.115
*	806	SA 114 750	22:41:45.00	+01:12:38.0	2000.0	11.916	-0.041
*	807	SA 114 670	22:42:10.00	+01:10:17.0	2000.0	11.101	1.206
	805	SA 114 548	22:41:37.00	+00:59: 7.0	2000.0	11.601	1.362
	209	SA 114 755	22:41:22.00	+01:12: 6.0	1985.0	10.908	0.571
*	823	SA 115 420	23:42:36.00	+01:05:58.0	2000.0	11.161	0.468
	824	SA 115 271	23:42:41.00	+00:45:10.0	2000.0	9.695	0.615
*	825	SA 115 516	23:44:15.00	+01:14:13.0	2000.0	10.434	1.028

Appendix C

Transferring files to NMSU

There is a simple script available to transfer image files from a given night down to a disk on ganymede at NMSU. Using this script, you can specify which images to transfer, and also, at what time the transfer will take place. It is important to try to minimize the network traffic from APO during the night when possible, because the 3.5m is often operated remotely and can suffer from poor network performance. Consequently, we recommend doing large image transfers early in the morning, after the 3.5m has closed, but before the network down at NMSU gets busy; 7 am is a generally good time. Of course, if you are observering remotely and have been using +XFER, then your images will have already been transfered as you took them.

To run the transfer script, simply use:

dosftp *date time*

This will transfer all the images from the specified date at the specified time; if not time is specified, the image transfer will start immediately.

For example, to transfer images from 981108 at 7am, use

dosftp 981108 7am

The images will be placed in /home/1m/*date*, viewable from all of the Linux machines at NMSU.

Appendix D

Transferring files to the telescope control program

You may wish to access two types of files from the telescope control program: script files with lists of commands, and user coordinate files with your object names and positions. To do so, you must first transfer these files to the appropriate location on the telescope control computer (loki).

You can do this using the command

copyscript *filename*

This will put the specified file (either script or coordinate file) in a scripts directory on loki under a subdirectory given by the username of the account from which you are running the command. For example, if you are logged in as holtz, the files will go in a holtz/ subdirectory. This allows different users to have script/coordinate files of the same name without conflicting with each other.

To access files copied with copyscript using the INPUT or OF commands, specify the file as username/scriptname, e.g.:

INPUT username/scriptname

Appendix E

Robotic operation notes

E.1 Input file format

A separate file can be prepared for each night's observing. The file should have the name *yymmdd.inp* where yy, mm, and dd refer to the **UT** date of the observation (i.e. the date after midnight). The observing file is used to customize what sort of observations will be made, various observational parameters, set of filters to use, and will provide a list of potential targets and exposure times for each target.

A sample file can be viewed (in a separate browser window) here.

It is important to follow the correct file format. The first line is a header line that is ignored, but it should be used to label the values used in the second line. The second line has 9 numerical entries:

1. DTFOC: minimum time interval between refocussing, in hours (suggest 2 hours?)
2. DTEMPFOC: temperature difference that will trigger a refocussing attempt, even if DTFOC has not elapsed, in degrees C (suggest 2?)
3. PHOTOM: flag to trigger automatic observations of standard stars, set to 0 for no standards, 1 to do standards
4. DTLOW: if PHOTOM=1, sets time interval between observations of low airmass standards with airmass between 1 and 1.3 (a pair will be taken each time)
5. DTHIGH: if PHOTOM=1, sets time interval between observations of high airmass standards with airmass between 1.6 and 2.0 (a pair will be taken each time)
6. LDOME: flag to determine whether the lower dome slit will be opened (1 to open, 0 to leave closed). The lower dome will begin to occult the telescope at an airmass of about 2.0. The reason not to open the lower

dome shutter if you don't have to is because the lower dome shutter is less robust to both computer and mechanical failures than the upper dome, so there is a larger chance that it will not close if something goes wrong.

7. NPM: number of pointing models to run before starting observations
8. NFOCTEST: number of focus tests to run before starting observations (these are engineering tests, not normal focus runs, which are always done).
9. DAYTEST: flag to use a test mode where dome is not actually opened, allowing script to be run during daytime or bad weather for testing purposes only; 0 for normal operation, 1 for test operation

The third line is another header line, this time for filter information. The fourth line stars with a number that gives the total number of filters that will be used for the night; each entry for each object will have to specify exposure times for each of these filters (although one can certainly specify 0 length exposures to skip any desired filter for any desired object). After the number of filters, there should be nfilt entries giving the filter names, where the names are those as used by the control software for setting the filter (i.e., u, b, v, r, i, z, c); case is not important (although I prefer lowercase for consistency). For each of the specified filters, the program will attempt to get twilight flats, and also observations of standard stars if the PHOTOM flag is set; consequently, you don't want to include filters in this list that you won't need observations in.

The fifth line is a header line again, this time for the remaining object lines.

Starting with the sixth line, information is given for each desired object. The software works by observing the first object in the list that satisfies a set of requirements. The requirements are that the object has not already been observed the requested number of times, that sufficient time (as defined by the observer) has elapsed to observe the object again, and that the object falls into a desired window in airmass, UT, or hour angle. If all conditions are met, then the object will be observed for the amount of time in each filter specified on the object line.

IMPORTANT: the object lines are parsed by looking for white space between columns. As a result, you must not include any "extra" white space, e.g. in an object name or in the coordinates!

For each object, there needs to be $14 + nfilt$ entries on the line. The entries for the object lines are:

1. Object name. **No spaces are allowed!**
2. RA, in format hh:mm:ss (No spaces allowed)
3. DEC, in format +/-dd:mm:ss (No spaces allowed)
4. Epoch of coordinates
5. Minimum airmass to observe (at start of sequence)

6. Maximum airmass to observe (at start of sequence). To ignore airmass criterion, set minimum airmass to 0 and maximum airmass to 99.

7. Miminum UT to observe (at start of sequence)

8. Maximum UT to observe (at start of sequence). To ignore UT criterion, set minimum UT to 0 and maximum UT to 24

9. Minimum HA to observe (at start of sequence)

10. Maximum HA to observe (at start of sequence). To ignore HA criterion, set minimum HA to -12 and maximum HA to 12

11. Maximum number of visits, i.e. after this many sequences have been obtained, this object will be skipped. To request "infinite" repeats, set this to a very large number.

12. Minimum time between sequences, in hours. To request continuous coverage, set this to 0.

13. Guide flag, 1 to use guiding during exposures, 0 for no guiding (guiding recommended for sequences over 60s).

14. Exposure times in each of nfilt filters, in the order in which they are specified in the filter line (4th line of file).

15. Number of exposures to take in each filter during the sequence.

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6. LDOME: flag to determine whether the lower dome slit will be opened (1 to open, 0 to leave closed). The lower dome will begin to occult the telescope at an airmass of about 2.0. The reason not to open the lower dome shutter if you don't have to is because the lower dome shutter is less robust to both computer and mechanical failures than the upper dome, so there is a larger chance that it will not close if something goes wrong.

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The fifth line is header line again, this time for the remaining object lines.

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6. Maximum airmass to observe (at start of sequence). To ignore airmass criterion, set minimum airmass to 0 and maximum airmass to 99.
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12. Minimum time between sequences, in hours. To request continuous coverage, set this to 0.
13. Guide flag, 1 to use guiding during exposures, 0 for no guiding
14. Exposure times in each of nfilt filters, in the order in which they are specified in the filter line (4th line of file).
15. Number of exposures to take in each filter during the sequence.

Appendix F

Telescope recovery notes

- Positive z motion sends rotator counterclockwise
- Positive x motion sends azimuth counterclockwise from above
- Recovery mode.
  1. Start code (telpos.sav) and position rotator (PC) to be clockwise from home position.
  2. Stop tocc.
  3. Set last position of rotator to 0 in toccscf.new, and saved_pos to be -9999.
  4. Restart tocc, and initialize