An Observer's Guide for the 2.4m Hiltner Telescope

John Thorstensen, Dartmouth College

with contributions from Jules Halpern (Columbia) and Rick Pogge (OSU)

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Preface

MDM Observatory's 2.4m Hiltner telescope is among largest telescopes in the world that always operates without a night assistant. In order to use the telescope effectively - and to avoid damage! - it's therefore essential that all observers be familiar with how it works.

This document is a guide to observing with the 2.4m. It contains checklists for operating the equipment, designed to prompt experienced users who haven't observed recently, and more detailed sections intended to elucidate common procedures for novices. This document is *not* intended to replace the more detailed manual in the control room (also available in a web-based version). When in doubt, "Read The Fine Manual".

If you're preparing for your first run at MDM, you'd be well-advised to watch the instructional videotape which I recorded back in 1996 or thereabouts. Although many of the details are out of date, it's mostly still current, and it gives a sense of the look and feel of the operation which you can't get from a verbal description. There should be a copy of the tape at each Consortium institution.

I should be careful here to note that *novice observers must be trained at MDM in person by a qualified observer before they can observe alone*. MDM has a very small staff, and there simply are not enough people on site to train novices. Since novices are likely to peruse this guide before their first run, I include some material aimed at them, but novices must not arrive expecting to teach themselves how to observe. Seasoned observers with extensive experience elsewhere may be able to get by on their own. However, if you are such an observer, you should be especially careful not to be overconfident - MDM has many idiosyncracies, and you ignore them at your peril. Don't forget, there's no night assistant to get you out of jams.

Organization of this Guide

The first part of this guide is a set of terse checklists to prompt the experienced but slightly rusty observer. The second gives detailed checklsts, a version of the terse lists in which every step is explained in detail. The third is a set of remarks for the first-time observer, essentially an attempt on my part to resurrect some of the good aspects of the observing culture I grew up with. Subsequent chapters offer overviews of the important telescope systems: computers, telescope, MIS, autoguiders, and ccdcom, the latter in the context of some instrument combinations I'm familiar with.

Note that there are quite a few instrument combinations available, some of which I've never used personally. I'll try to make clear when an item or a statement refers only to a particular setup.

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Terse Checklists

Before the Run

- fill out Web-based observing run form (linked here).
- clear early arrival with previous observer

- generate coordinate list files if needed
- blank data tapes (4mm DAT or 8mm Exabyte, DAT preferred).
- observatory computers run Unix and Linux, with XWindows - familiarity advisable.
- ensure ssh available on home machine.
- note that personal phone calls from the observatory must be on credit card or collect.
- if you take meals at Kitt Peak, you'll need check or credit card to settle up the charges.
- if bringing laptop, learn how to configure for fixed IP address or DHCP.

First day

- check out instrument as needed
- be sure you know the current visitor password
- copy your coordinate file(s) to chichon
- review any local manuals
- if lightning is a possibility, review shutdown procedure
- if first-time observer, walk through procedures and learn as much as possible
- become aware of water and electric power conservation

Opening

- *verify* safe weather conditions
    - RH <85 percent
    - mirror temperature well above dew point
    - wind <40 mph
    - no threat of precipitation
    - no dust
- *verify* that mirror support is working
- open dome
    - main shutter (punch once)
    - dropout (push and hold 'til open)
- open louvers and optionally garage door
- top off instrument dewar if needed
- open instrument dark hatch
- *verify* dome fully open (it can stick!)
- *verify* telescope free
    - platform all the way down
    - ladders, storage dewars, etc all cleared
- go to control room

- set dome azimuth readout to 320 degrees if needed
- enable dome control if needed (yellow button)
- clear link; set UT
- START button on black TCS control box
- silver switches on black box:
  - drives on
  - track on (*verify* telescope tracking)
  - mirror cover open
  - auto-dome on
  - dome free
  - autoguider enabled
- go out in dome and *verify* that all four mirror petals are up
- check dome lights off, control room window dark shade closed
- take sky flats?
- *verify* TV gain all the way down before powering on
- turn on guide TV monitor
- look up a bright star near zenith in Almanac
- slew to bright star
- if using MIS, configure so TV should see bright star:
  - find/guide mirror to GUIDE
  - TV selector to GUIDE (unless CCDS, which has its own slit viewer)
  - If working direct, guide probe to CENTER; if Modspec or MkIII, to SLIT
  - advance TV image tube gain SLOWLY until star is visible
- set TCS readout epoch to Almanac bright star epoch
- When bright star centered, set the RA and Dec
- *verify* coordinates have set correctly.
- set TCS readout epoch for night's observation (2000?)
- focus telescope as needed
- proceed!

During the Night

- keep an eye on the humidity
- step outside from time to time to monitor weather
- go into dome from time to time to check dome alignment

Closing

- TV gain down, image tube power off, TV monitor off.
- Slew to zenith.
- reset instrument rotator to 0 degrees if needed.
- close mirror covers (do *not* move rotater with mirrorcover closed).
- set accurately to zenith; track off, drives off.
- all other switches down. Dome goes home.
- hit red STOP button on TCS black box
- dome lights on
- close instrument dark hatch
- close dome.
  - if dome did not return to contacts, hit yellow button and tweak manually.
  - dropout must close before main shutter
- top off instrument dewar
- close louvers and garage door
- verify dome fully closed
- back up data to tape
- check air conditioner; adjust if needed
- record any messages for staff (e.g., filter changes) on whiteboard
- fill out the Nightly Observing Report Form. Also fill out a trouble report form if you encountered any problems (even ones you fixed yourself).
- go to bed!

At the end of your run

- Plan to leave mountain as soon as practicable; keep staff informed
- Pay your meal bill (afternoon of last business day before your departure.)
- Check with staff about whether to fill dewar
- Make arrangements to get off mountain if needed
- Be sure all your data are properly backed up
- Tidy up control room; erase grease-pencil markes from TV
- Throw away food and wash your dishes
- Strip your bed; stuff used linens and towels in pillowcase and leave by linen closet
- Leave your bedroom tidy
- Check bedroom windows closed, heater off, no water leaks
- Look around to be sure you haven't forgotten anything!

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Annotated Checklists

Before the Run

Fill out Web-based observing run form.

> It is *essential* that the staff know your plans with *two weeks'* advance notice. Observers who do not fill out their observing forms run the risk of forfeiting their time!! Go to http://www.astro.lsa.umich.edu/obs/mdm/ and bring up the Observing Preparation Form. Note that there's also much useful information on this page.

Clear early arrival with previous observer.

> It's a good idea to arrive the night before your observing run in order to settle in and acclimate. This is doubly so if you're a first-time observer. However, you can only do this with the knowledge *and permission* of the previous observer. Be sure to contact them well in advance to ensure it's OK. The MDM schedule is on the web. If you don't get permission you'll just have to stay downtown, perhaps at the Plaza hotel at Campbell and Speedway.

Generate coordinate list files if needed.

> If you have a lot of targets, you can save considerable time at the telescope by preparing coordinate lists ahead of time. The TCS (telescope control system) expects one object per line of the form

```
my_object 18 23 23.28 -0 14 14 2000
```

> where the fields are a name *without blanks*, the RA and dec in the usual sexagesimal form (hours minutes seconds and degrees minutes seconds), and the coordinate equinox (i.e., "epoch"). Note that you can't use colons to delimit the fields - they have to be blanks. Otherwise, the format is free (you don't have to get the information into specific columns). You'll be selecting objects from the list by typing their names, so you'll want to make the names simple and mnemonic (e.g., tausource rather than 4E_0235.27389+123457-a).

Blank data tapes.

> This is instrument-dependent, since the MDM 8K CCD Mosaic Camera uses its own tapes; otherwise, 90m DDS-1 DAT tapes work fine. Note that because of the limited bandwidth, it's completely impractical to send large amounts of data across the Internet from MDM you must be ready to put them on tape. Small amounts of data (such as 1-dimensional reduced spectra) will transfer in a reasonable amount of time, but only a handful of direct images can be transmitted.

Observatory computers run Unix and Linux, with Xwindows - familiarity advisable.

> If your home computing environment is Unix, you'll quickly figure out the MDM environment. If you're not familiar with Unix, you should learn the rudiments - how to list directories, change directories, copy and remove files, send mail, and so on. You'll want to know the tar command for making tapes. More advanced users may want to review the dd command so that they can write scripts to drive it; that writes images to tape as individual files. The observatory computers interact through Xwindows, using the fvwm2 window manager. Most observers won't have any particular issues with it, but if you've been in a cave for the last few decades you might want to look into it.

Ensure that ssh is available on your home machine.

If you anticipate communicating with a machine at home, you should anticipate using the ssh ("secure shell") protocol. Otherwise you'll be sending passwords in clear over the net. That means installing ssh and sshd on your home machine and ensuring that its daemon is properly started at boot time. Your home system administrator can help with this. Either ssh1 or ssh2 is acceptable.

If bringing a laptop, learn how to configure it for either fixed IP address or DHCP operation.

There's a network port which can be used for a laptop. There are two ways to connect your laptop: fixed IP address or DHCP. If you are configured already for the latter, you are all set. If the former, please follow the instructions in the Guest Computer HowTo guide in the control room.

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First day

Check out instrument as needed.

This is obviously instrument-dependent. Spectrographs in particular may require substantial tweaking (focusing, setting spectral ranges, etc.). If you're a first-time observer you'll want to spend some time familiarizing yourself with the equipment and the observatory.

Be sure you know the current visitor password.

The password for the visitor account changes frequently. If anything crashes you'll need it to get back up, so be certain you have the correct password.

Copy your coordinate file to chichon.

If you have one, put your coordinate file in the home directory of visitor on chichon. You could copy it from from your home institution using scp.

Review any local manuals.

Autoguiders in particular might use a review at this point.

Even if the weather is clear, review the emergency (lightning) shutdown procedures.

A single lightning strike can (and does) take out the observatory for many weeks. There is a procedure for shutting the equipment off when lightning threatens, and it's important that you do all the steps in order. Find the documentation and walk through it if lightning could occur.

If you are a first-time observer, walk through procedures and learn as much as possible.

You should have a qualified observer there to do this with.

Become aware of water and electric power conservation

Both these utilities are extremely expensive on the mountain. Start getting in the habit of conserving them as much as possible. Shower quickly and efficiently (difficult since there's a very long run of pipe between the heater and the rooms), be especially aware of water leaks (especially things such as as running toilets), run lights and heaters only when necessary, and so on.

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Opening

Verify safe weather conditions.

- RH <85 percent
- mirror temperature well above dew point
- wind <40 mph
- no threat of precipitation
- no dust

Note that there's a little Davis weather station readout by the computer room door, which includes a wind gauge and an outside humidity gauge. There's also a humidity sensor on the mirror air conditioning computer - the sensor readout display is a menu choice on the A/C computer, and you can get the menu by typing esc (escape). Under rare and unfavorable conditions the mirror can have ended up below the dew point - in this case you obviously can't open even if the RH is nominally OK, and you'll want to *warm up* the mirror by reversing the air conditioner (there's a menu choice); this actually works. The wind limit is pretty liberal, since a 40 mph steady wind is really howling. If the air is dusty (dust storms do occur), you must not open, even if the wind is below the limit.

verify that mirror support is working.

The mirror support computer is in the left-hand computer rack. There are three numbers showing forces on the three hard points which position the mirror - they should all be within a couple pounds or better of the nominal value of 30 pounds. The telescope *cannot* be moved unless the mirror support air bags are working - moving the telescope without the air bags being up can damage the mirror support system! (Your images would be lousy anyway.)

open dome.

- main shutter (punch once)
- dropout (push and hold 'til open)

The dome shutter controls are on the northwest wall of the dome. In order for electrical power to get to the shutter, the electrical contact boxes mounted on the dome and the building need to be lined up. Unless the dome has been moved since it was closed, they'll be lined up. [If the shutter doesn't respond, try moving the dome slightly to get better contact on the electrical feed box. If it still doesn't work after several tries, {\it move the contacts off the electrical feed box} and use the backup cable. Don't plug in the backup cable with the dome near the feed box -- that can create a short!]

open louvers and optionally garage door.

The dome building walls have louvers which you can open to allow ambient air to circulate through the dome. You can also open the garage door by the loading dock, though doing so carries a slight risk of allowing in the local fauna (skunks have been known to wander in. No pumas so far). Allowing ambient air to flush through the dome helps the temperature equilibriate and greatly improves the seeing.

top off instrument dewar if needed.

This depends on the instrument. If you've filling one of the MDM dewars mounted in an upward-looking position, *be sure* that the fill tube is *all the way up*, or you'll get a false fill and likely warm the dewar up during the night.

Note carefully that *dewars must be kept cold under all circumstances, and cannot be refilled if they're allowed to warm up.* Once a dewar warms up, any volatiles remaining boil off into the vacuum, and if you cool the dewar down without first pumping on it there's a serious risk of getting gunk on the CCD. Only the staff can pump a dewar, it's a fairly complicated operation.

In the upward-looking configuration it is especially important to insert and remove the fill tube straight, without pulling or pushing sideways, as this can loosen the internal fitting which holds the LN2 and create a slow leak; your hold times will go down to a couple of hours if that happens.

Open instrument dark hatch.

Near the top of the MIS there's a little knurled handle - pull it down to release it and flip it to its other position. This opens a dark hatch at the top of the instrument. If instead it feels like it's falling and goes "clunk" then you've closed it (the previous observer left it open by mistake!). The MDM 8K camera has its own dark slide.

verify dome fully open (it can stick!).

The dome has been fixed and shouldn't stick now, but you can't be too careful. In the past the the shutter has tended to stop up on various rough spots on the track, and *think* it's open. There was a particularly insidious one which leaves about 2 feet of dome in the zenith. Check carefully with a flashlight if needed to be sure the dome is open all the way. If it isn't, hit the open button again and it should continue.

Incidentally, note that the telescope beam is occulted slightly near the zenith even when the dome is fully open. See the full manual for a tabulation of this zone.

verify telescope free

- platform all the way down
- ladders, storage dewars, etc all cleared

The lift platform must be all the way down, or an interlock cuts power to the telescope. When you're tired or in a hurry, it's easy to make bonehead errors like slewing the telescope with a storage dewar still attached. Just check to be sure the space around the telescope is clear of obstructions.

Return to the to control room

set dome azimuth readout to 320 degrees if needed.

The dome position readout sometime loses pulses and the dome readout becomes inaccurate. If this happened the last time the telescope was used, you'll have to reset the dome position. To do this, go to the xtcs window on Chichon, select setup and set dome azimuth. You set the azimuth by typing 320 (the azimuth at which the electrical contact boxes are lined up) and hitting carriage return.

enable dome control if needed (yellow button).

If the dome had to be manually tweaked onto the electrical contacts the last time it was closed, it was probably left in manual mode. This is controlled by a big square yellow button at the bottom of the left-hand computer rack. If this button is pressed in, the dome can be rotated by the computer (and not by hand); if it's not pressed, the dome can only be rotated by hand (using the wall-mounted box in the dome). The yellow button should light up when pressed.

clear link; set UT.

Use the setup menu on xtcs for these commands. They just make sure the TCS control computer is ready to receive commands and that its clock is set correctly. Incidentally, the observatory clocks are set using the network time protocol. If timing is critical for your observations, there's a rack-mounted WWV clock at the 1.3m you can use to check the observatory's time.

START button on black TCS control box.

The green START button should come on and stay on when pressed. If it immediately goes out, you probably forgot to lower the platform all the way and you're being locked out.

silver switches on black box:

- drives on
- track on (*verify* telescope tracking)
- mirror cover open
- auto-dome on
- dome free
- autoguider enabled

Basically, all the silver switches should be in the up position to observe. The external computer switch is obsolete and doesn't do anything.

When you flip the track switch up, you should see the RA stop changing on the TCS display, and the HA start moving. If it doesn't, there's a problem.

go out in dome and *verify* that all four mirror petals are up.

The mirror petals are driven open by a pneumatic air system. If there's a failure in that (e.g., ice in the lines) they may not come up; also, they barely clear the sky baffle so they sometimes hang on that.

Clearing a hung up mirror cover petal is an intrinsically dangerous operation, but here are the instructions if you wish to try. Alert the 1.3m observer and have them come up to watch, or at least tell them that if you don't get back to them in 10 minutes they must come up to summon aid in case you injure yourself. Using the control paddle stored on the west side of the telescope, slew the telescope way over so you can get access to the sky baffle. Get the aluminum ladder and a stick about 5 feet long (e.g., a broomstick). Get up on the ladder. *That petal is going to open explosively!!! Look out where it's going to go before you do anything!!!!* Once you're sure you won't be knocked off the ladder by the opening petal, gently push on the sky baffle to free the cover. BAM! - the cover opens *violently*. Stop shaking and climb back down. Tell the 1.3m observer that you're OK.

check dome lights off, control room window dark shade closed.

Simple stuff but forgettable.

take sky flats?

If you're working direct, and want to use the twilight sky for flatfield information, now is the time to get the flats. There's only a short time window (about 10 minutes) a little after sunset when the sky is the right brightness for this, so you have to be on the timeline.

You need at least three usable sky flats per filter, so that stars can be medianed out. Don't forget to move the telescope by a field width or so between exposures to make this possible.

Exposure times are problematical, especially since the readout time may be comparable to the timescale over which the sky changes. Note that the skycalc program is available on the observatory computers, which has a feature which computes the twilight sky brightness. Setting skycalc to automatically update the program time (xU) lets you monitor the sky brightness with the = command. If you write down the exposure time, filter, average counts and skycalc's computed sky brightness, you can use the information to set the exposure time on other sky flats (in the morning, for instance).

verify TV gain all the way down before powering on

The MIS TVs consist of Gen-1 image tubes feeding naked, uncooled video-rate CCD cameras (the MDM 8K camera has its own guide TV). The image tubes are fed by a power supply which has a red power button on it. The image tubes have an *extremely* long RC time constant - many minutes!! - so once the gain is up, it's up. You're about to look at a bright star, and it's a good idea not to have the gain up too high. Therefore, be sure the voltage-control knob on the power supply is should be turned all the way down (left) before powering on.

turn on guide TV monitor

look up a bright star near zenith in Almanac

slew to bright star

Unless you've pre-selected the bright star, you'll have to enter the coordinates in the xtcs window, with epoch, then hit the Send Coordinates button to upload the coordinates to the TCS, then hit the Go button to slew the telescope. Unless the dome just happens to be in position, you should hear the dome rumble. If you don't, be sure the dome really is in position.

if using MIS, configure so TV should see bright star:

- find/guide mirror to GUIDE
- TV selector to GUIDE (unless CCDS, which has its own slit viewer)
- If working direct, guide probe to CENTER; if Modspec or MkIII, to SLIT
- advance TV image tube gain SLOWLY until star is visible

set TCS readout epoch to Almanac bright star epoch

Almanac lists are for the middle of the year. You'll want the TCS epoch to match the Almanac so you can check it.

When bright star centered, set the RA and Dec

This *should* set the encoders to the "next object".

verify coordinates have set correctly.

If you mess up here, you'll lose some time fixing the problem, so before you leave the bright star you'd better be certain the coordinates did set correctly. Occasionally they don't (usually operator error).

focus telescope as needed

This is instrument-dependent. If you're working direct, you'll probably want to get to your first object and run focus frames for your filters. If you're looking at spectrograph slit jaws, put a star near the slit jaws and focus by eye. You'll want to use a relatively unsaturated image for this, so a bright star is probably not the best. The focus star should be near the slit jaws since the slit is inclined to the focal plane.

Telescope focus depends primarily on temperature; there's a feature on the A/C control computer which, once you set it, computes a suggested focus based on the temperature of the telescope's truss. In my experience this doesn't work perfectly but gives some idea as to which way things are going.

proceed!

Take some data! There are some remarks later in this Guide about autoguiding, and there are good manuals at the Observatory for both guiders.

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During the Night

keep an eye on the humidity

Episodes of high humidity can occur any time of year without warning. If you set the mirror air conditioning control computer so that the blue readout screen is on, a warning will flash if the RH rises above 85 percent. This catches the eye very effectively, provided you glance around from time to time.

step outside from time to time to monitor weather

This is always good sense, and it makes for a welcome break from the noisy control room.

go into dome from time to time to check dome alignment

As noted earlier, the dome can lose track of where it is, since the dome position system apparently picks up noise pulses from time to time. Even small inaccuracies can be a problem, since the dome slit is only a little wider than the telescope beam. The dome azimuths are marked with red reflective tape on the walls; it's a good idea to check it from time to time. I once discovered a dome problem when I saw a sawtooth light curve from the check star in a time-series photometry run - don't let it happen to you!

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Closing

TV gain down, image tube power off, TV monitor off.

Once you're no longer looking at the sky, turn 'em off. Leave the guider PC on.

take sky flats?

See the earlier discussion under Opening for details. If you've written down the exposure data on previous mornings and evenings, it should be possible to get a fairly good exposure the first time.

slew to zenith.

An easy way to do this enter coordinates

```
RA  = sidereal time + 1 minute
Dec = 31 57 12
Epoch = now (in decimal years)
```

into the xtcs window, and slew.

reset instrument rotator to 0 degrees if needed.

If you've rotated the instrument and it's in some funny position, you should set it back to zero, at least on your last night. Remember that the mirror covers must be open to rotate the instrument!!

close mirror covers (do *not* move rotator with mirror cover closed).

You should ideally be near the zenith to close the mirror covers, though in an emergency you should just go ahead. To do this, flip the silver switch on the black panel down. You'll hear the four of them crash down, hopefully in order.

set accurately to zenith; track off, drives off.

It's worthwhile to get the telescope dead straight up, since then you know exactly where it is if there's some kind of problem (e.g. a lightning shutdown). Turn off the tracking and set the hour angle to zero.

all other switches down. Dome goes home.

hit red STOP button on TCS black box.

dome lights on.

close instrument dark hatch.

close dome.

- if dome did not return to contacts, hit yellow button and tweak manually.
- dropout must close before main shutter

Note that the main shutter takes a while to close, so you can get it started first, and then hold down the dropout close button until it slams shut. If you need it, the yellow auto-dome enable switch (discussed earlier) is in the computer room at the bottom of the left-hand rack.

If there's a problem getting power to the dome - for example, if the rotation fails and you can't get it on the contacts - there is an emergency cable which can be connected. See the full manual for details.

top off instrument dewar

Doing this as the dome is closing is a good habit. Don't forget to mark the time on the whiteboard. See earlier cautions on filling upward-looking dewars and not filling warm dewars.

close louvers and garage door

verify dome fully closed

back up data to tape

If it isn't on tape, it didn't happen.

The Unix tar command is the most reliable way of doing this. On agung you might create a subdirectory of the data you wished to back up (called "subdir") and in the directory above it type

```
tar cvf /dev/nst0 ./subdir
```

A similar operation can be done on chichon, but there the DAT tapedrive is named /dev/nrst5.

Observers sometimes get into trouble by leaving their tape copying to the last day. Not only does this leave you vulnerable to disk or computer failure, it can cause problems if you underestimate the time required, leading to collisions with the next observer. Back up every night, and be sure that your plans for writing tapes the last morning of the run are realistic.

check air conditioner; adjust if needed

Once the mirror petals are closed, the air conditioner will try to cool the mirror to a settable temperature, because the seeing goes bad in a hurry if the mirror is more than 1 degree C or so warmer than ambient. The mirror has a long thermal time constant (like 12 hours), and the air conditioner is not particularly effective at cooling the mirror, so if you want to adjust the temperature for the next night, better do it now.

How to decide on a temperature? The A/C control program has a feature which displays the history of the ambient temperature, the mirror temperature, and the temperature set point for the last 3 days or so. Detailed weather forecasts are available on the web; the National Weather Service Tucson office (http://www.wrh.noaa.gov/Tucson/twc.html) has a terrific site which includes very technical details of the forecast. If humidity could be an issue, you'll want to be careful not to overcool the mirror.

record any messages for staff (e.g., filter changes) on whiteboard

If you have any requests which will require timely action by the staff, please be certain to write them out legibly on the whiteboard. You cannot expect to wake up at 3 PM, saunter out of bed, and tell the staff to drop whatever they're doing and swap out all your filters. In this, and everything else, try to think ahead, both to assure that your requests can be handled and to minimize the strain on our very small staff.

Fill out the Nightly Observer's Report Form.

MDM requires that all observers fill out a brief report of the night's activities. To make this as painless as possible, a simple web form has been created that is accessed from the mountain top web server (http://chichon.kpno.noao.edu/). Even if you did not observe, you should fill out a report saying why.

Nightly observing reports are stored on the mountaintop server, and emailed to a short list of recipients that includes the observatory directory, mountain superintendant, and the MDM consortium representatives from each member institution. Report data are used to track how much observing time is lost to weather, problems, etc., as well as to keep a permanent record of activities.

Similarly, if you encountered any problems at all, even ones you fixed yourself (i.e., not common mistakes but real problems that required you take some special action to continue working), also fill out a trouble report. There is no such thing as a "minor" trouble report. Often a big problem starts as lots of little problems or quirkly annoyances. If we can see a pattern develop in the trouble logs, we might be able to head off bigger problems later. Remember, the run you save could be your own!

go to bed!

Your program may call for instantaneous data reduction - if so, bring a collaborator or automate it so you can get enough sleep. It's important not to get too tired!

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At the end of your run

Plan to depart as soon as practicable; keep staff informed

Accomodations at the Obsevatory are very limited, and the next observer should not have to work around you as they set up and settle in. Accordingly, observers are required to leave the mountain as soon as they can, ideally by the early afternoon of the day after their last run. Please keep the staff informed of your plans. If you intend to sleep for a while after your final night, be sure the staff knows when you intend to get up and leave, or they have no idea what to tell the next observer about bedroom availability and so on. The instant-departure rule can be relaxed when there is a very good reason (e.g., packing up a complicated user instrument at the end of a run), but exceptions must be cleared with all concerned!

Pay your meal bill (afternoon of last business day before your departure - you cannot pay your bill on weekends!)

If you've taken any meals up at the Kitt Peak cafeteria, you're to pay for them before you leave. This is at the main office of the Admin building up top. You can dial zero on the phone to tell Joanne (usually) that you're departing and have her make up a receipt for you.

Check with staff about whether to fill dewar.

Sometimes the staff may want the dewar to run low because it makes it more convenient for them to change the instruments.

Make arrangements to get off mountain if needed

If you're using the Kitt Peak shuttle you'll have to reserve a spot; the schedules are kept in the Admin building up top. MDM pays an annual fee so that observers may use the shuttle; we are not charged by the passenger, so go right ahead. MDM users may not drive Kitt Peak vehicles, so you can only use the 'U-drive' schedule options when someone else is driving.

If you're using an MDM vehicle to get off the mountain, you'll have to arrange it ahead of time with the staff. Be sure to give the staff plenty of advance notice!

Be sure all your data are properly backed up

Standard operating procedure is for the staff to simply wipe out your data from the observatory computers as soon as you're gone (though if you ask real nice they can sometimes be persuaded to leave your data alone until you verify your tape is legible at home). It's therefore a good idea to write more than one copy of your data. I've taken to writing the data both on Chichon's tape drive and on Agung's drive (Agung is the Linux box), to avoid the possibility of a maladjusted drive (sometimes DDS drives get in a condition where they can only read their own tapes - not too useful for export). I generally leave one copy of the data in the Dartmouth cabinet at the observatory in case there's some kind of problem on the way home.

Be sure to allow sufficient time to back up your data. You should plan your tape writing carefully so that you're finished early enough to allow the staff to start instrument changes when they arrive at 8 AM. As noted earlier, you should be backing up your data as you go along anyway.

Tidy up control room; erase grease-pencil marks from TV

Gather up all your charts, scratch paper, whatever, and leave a neat workspace for the next observer. If you've marked up the guide TV monitor with grease pencils, erase all those marks now -- they probably won't apply to the next observer. (Incidentally, you should never write on a *computer* monitor, and you should be sure to use easily eraseable grease pencils if you feel you must make marks on a TV monitor. I never do this anyway, since there are cursors to mark things.)

Throw away uneaten food and wash your dishes

There's a tiny refrigerator and larder in the kitchenette -- space is very limited, so don't leave behind anything which could go bad. Who knows when that half-eaten sandwich was parked there, anyway? There are vermin (verpersons?) at the observatory, so you should never let dishes pile up, but if you have, better get 'em now.

Strip your bed

Stuff your used linens and towels into one of your pillowcases and leave by linen closet.

Leave your bedroom tidy

There's no chambermaid. Behave accordingly.

Be certain bedroom windows closed, heater and lights off, no water leaks

As noted earlier, water and electrical power are extremely expensive on the mountain. No one else is going to check your room to be sure you've turned things off, so be especially careful that you do. Be sure the toilet isn't running!

Look around to be sure you haven't forgotten anything

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Acculturation for New Observers ...

I trained as an observer at Lick in the 1970s. At that time new observers were walked through procedures by seasoned staff observers. This certainly got the job done - we learned the equipment - but in the long run, the most important lessons we learned from this were not about which buttons to push, or how to develop plates. They were instead lessons about the experience of observing, and the attitude to bring to the telescope. As an old curmudgeon I think some of these lessons have atrophied over the intervening years, as overworked faculty pack students off to observe with minimal preparation. Here's a distillation of some of that acculturation, as refined through many hundreds of nights of observing experience since then, most of them at MDM.

- Telescope time is precious, and using a large telescope is a privilege. You should feel a strong obligation to use your time well.
- Accordingly, it's important to be efficient. This means giving some thought to your procedures. It also means having a well-thought-out and well-prepared program. I remember one famously efficient observer who was said to have spent three nights of large telescope time efficiently observing the wrong list of objects - he'd grabbed the "already observed" list instead of the "to be observed" list, and hey, galaxies all look alike!
- Be careful with the equipment. It's expensive stuff and carelessness is not an option. Leave everything in good working order. Report problems completely and carefully so that they may be fixed. Leave the control room in better order than you found it. And when conditions become dangerous to the telescope (blowing dust, too-high humidity, etc.), close immediately!
- Work very hard, but try to take care of yourself. If you get too sleep-deprived, you're liable to make really dangerous errors.
- Most primary programs require excellent conditions. What if your conditions are usable, but mediocre? What if the seeing is 2 arcsec instead of 0.7 arcsec? What if you require photometric conditions but there are high clouds? This happens a lot - have a backup program! If you can't

think of one yourself, ask around your department and collaborators - someone else is sure to need something.

- You should take a workmanlike attitude toward your data. Pictures should be in focus and centered. Spectra should be in focus and properly calibrated - and they should be of the object you intended! Take a few moments to get things right.
- On the other hand, better is the enemy of good. I remember a meticulous student who hardly ever took data because the conditions were never perfect enough for his high standards - he had the most wonderful dome flats, though. I actually witnessed a memorable scene in which an instrumentally-minded investigator spent most of a beautiful night fine-tuning equipment endlessly as the stars wheeled overhead and a roomful of European collaborators flown in for the occasion became increasingly exasperated. Telescope time is precious. Use it.
- Even though you should feel a strong obligation to use the time well, you'll be more efficient in the long run if you don't hurry. Hurrying leads to really big mistakes, like that poor guy observing the wrong objects.

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Computer System Overview

As of this writing (December 2000) there is an outdated section on the computer system in the official manual, and an FAQ document detailing extensive modifications and upgrades to the observatory computer system accomplished by Rick Pogge and Mike Savage in the summer of 2000. This little blurb doesn't replace either of those but might help get you started.

There are three computers at each telescope. At the 2.4-meter telescope, these are:

chichon:

: This is the main Observing Workstation where the observer logs in for most things. It is a Sparc 5 running Solaris.

agung:

: This is a PC running Linux configured as a Data Reduction Workstation. It is usually where any second observers will be able to login and work.

pinatubo:

: This is a Sparc 10 running Solaris configured for special data-acquisition tasks. pinatubo runs the MDM CCD cameras with a special interface, and is the data-repository for the OSU instruments (CCDS and TIFKAM).

chichon and agung run Xwindows on their main consoles, and have been setup to have a common look and feel. A large number of useful tools are in the desktop menus; you get at these by positioning the mouse on the screen background and depressing mouse buttons. The summer 2000 upgrade standardized these pretty well. The window system used has a bunch of desktops available - there's a little cartoon in one corner showing them all. The windowing system shouldn't present any problem for most users.

On all machines you login to a visitor account named visitor. Logging onto chichon as visitor puts you into the directory /home/chichon/visitor. In this directory there is a subdirectory named data that is a network link to the raw data disk on pinatubo named/data/pinatubo/visitor. In addition, there is a dedicated scratch data space on chichon named /data/chichon/visitor. The two "/data" disks each have approximately 17.8 Gigabytes of space. The "/data" disk on pinatubo is also mounted by the Linux workstation agung.

> **NOTE:**
> The disks on pinatubo used to be broken up into about seven <2 GB partitions. A new, consolidated raw data disk was installed in December 2000 which has a total capacity of about 17.8 GB. While it may be possible to fill this space up, too, at least you know your data are all in one place...

The telescope and the MIS (Multiple Instrument System, used for everything except the MDM 8K camera) are controlled from windows on chichon. There's one window called xtcs, which runs the telescope control system, and another called xmis, which runs the MIS. These controls are thoughtfully designed and should be fairly intuitive. The web-based manual has sample displays of these windows, in color.

The usual MDM CCDs (Echelle, Charlotte, Templeton, etc.) are run by a program called ccdcom. This has a text-based interface and runs on pinatubo. There's a menu choice on chichon for a ccdcom window, which automatically logs you onto pinatubo and gives you an xterm with yellow letters on a black background. You now cd to the directory you want your data in, and type ccdcom to invoke the ccd control program. There's a good manual describing ccdcom, and a later section of this Guide gives a little advice on the program.

Note that you can run everything from chichon's terminal - just ssh to the other machines as you wish. As the 2000 upgrade document details, agung can serve as a fast and capacious reduction machine.

There is a DDS-1 (low-density) DAT drive on chichon, and a more recent drive (DDS-3?) on agung. The MDM 8K camera has its own control computer and its own tape drive (high-density Exabyte).

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How the Telescope Works

The official manual contains a lot of detailed information on the workings of the telescope. Here's a short overview which may be helpful but which is necessarily very general.

The telescope is generally configured as an f/7.5 Ritchey-Chrétien - an f/13.5 secondary is seldom used. It has an equatorial fork mount, built by DFM engineering in the early 80s. The drives are unusual in that they do not have worm gears - rather, the telescope is driven by large steel wheels with smaller driving wheels pressed up against them.

The Telescope Control System, or TCS, is a PC containing a fair amount of custom hardware. In particular, it contains counters which listen to and interpret the pulses from encoders, and boards which issue signals to the power electronics "muscle boxes". These in turn send power to the stepper motors which run almost everything. The TCS dates from 1995, when the original custom computer which came with the telescope was retired. Because of limitations of the multitasking software available for PCs at the time, the operating system of the TCS PC is OS/2, which will be unfamilar to almost everyone;

luckily, observers should never have to interact with the OS.

The user interface for computer control of the telescope is through a program on chichon called xtcs. This is fairly easy to use -- to slew, just enter the coordinates and hit `send' and `go'. As noted earlier, this can be made more efficient by putting your target list in a file ahead of time and calling the objects by name. The xtcs window also allows users to reset the encoders, adjust track rates, and so on. It may be helpful to keep in mind that xtcs is just a user interface -- the actions are mostly occurring in the separate TCS computer. When the TCS computer program is running normally, the TCS computer's monitor displays the status of the telescope. It's designed to be similar to the old TCS monitor, so the comprehensive manual in the control room gives a fairly good idea of its function. I'd recommend that you peruse the monitor display carefully on your first day - you'll be looking at it a lot, so you'll want to understand what you're seeing.

Under most circumstances, the telescope points to about 15 arcsec rms or better. This figure can change depending on how recently the pointing errors have been mapped and modeled; the position as displayed has been corrected using a model of the telescope errors. The position displayed is also corrected for refraction, nutation, aberration, and precession, so it should approximate the mean coordinates for the specified equinox. The model (and the corrections) are handled correctly when the coordinates are reset using a known star. The telescope readouts sometimes drift slightly in declination during the night, especially if you do a lot of long north-south slews; apparently a few pulses from the dec encoder get lost.

Note that the telescope has some pointing limits. It can't get extremely close to the horizon, or various hard and soft limits are triggered (see the comprehensive manual for where these limits are and how to back out of them if you get into them). The RA is limited to +/-6 hours to avoid cable wrap problems. Observing under the pole is not really supported, though I hear it's been done.

There are manual control paddles to move the telescope. These have directional buttons NSEW, and two buttons labeled SET and SLEW. The actions of these buttons are quite standard. Holding a directional button down moves the telescope very slowly in GUIDE rate (typically one or two arcsec per second of time - the guide rate can be adjusted with the xtcs window). Holding down the SET button results in a much faster rate, about 1 arcmin per second. Finally, the SLEW rate is full-speed, around 1 degree per second, used for major repositioning of the telescope. If you need to slew manually, you must keep an eye on the telescope to be sure you know what it's up to.

Occasionally the telescope may lose pointing entirely. Hardware failures may be responsible; more frequently, it's due to pilot error (updating pointing carelessly and then slewing away before the error is detected). To regain pointing,

1. Turn off the tracking.
2. Manually slew to near the zenith.
3. Within a few degrees of the zenith, tiltmeters mounted on the telescope will read how far off the zenith you are. The readouts are on a rack in the computer room; zero them out by moving the telescope.
4. Type the coordinates of the zenith into the appropriate fields in the xtcs window; they are

```
        RA = sidereal time
```

```
Dec = 31 57 12
Epoch = right now (decimal year)
```

You'll want to choose a sidereal time a little in the future to allow time for typing and so on.

5. Send the coordinates to the TCS.
6. When the actual sidereal time on the TCS matches the RA you've set up, reset the RA and dec readouts using the command in the xtcs setup menu.
7. Verify that the hour angle is reading near zero and the dec is 31 57 12.
8. Turn the tracking back on.
9. Select and slew to a bright star and fine-tune the pointing. The tiltmeters only get you within a couple of arcmin, which isn't good enough for most purposes.
10. Select and slew to another bright star to check.

The telescope is focused by holding down the IN and OUT buttons on the paddle. This moves the focus rather slowly. If you also hold down the SET button, the focus moves much more quickly. The focus numbers are arbitrary and their zero point varies widely - your numbers from the last run mean nothing. Focus numbers tend to decrease as the temperature goes down.

There is an instrument rotator at the back of the telescope. It has its own encoder, which is not particulary reliable these days; you can set the encoder using xtcs. There are various pieces of tape marking different position angles. Note the following about the instrument rotator:

1. You *must* have the mirror covers open to rotate the instrument. The mirror covers bear upon a moving part of the instrument rotator! Metal shavings and paint flakes don't do much good for the mirror!
2. The rotator paddle is in the dome. Be sure to turn the speed all the way down before turning the rotator on or reversing direction.
3. While rotating the instrument, use a flashlight to watch carefully for any cables which might be hanging up. It's a helluva thing to have a cable catch on some critical switch or knob, pull it, and then get ripped out ... ruins your whole night.
4. To avoid problems with cable hangup, the rotator angle should be kept within +/-90 degrees.

On this last, note that there's a little quantity called the "slit angle" displayed on the TCS. The story behind this is as follows. If you do slit spectroscopy away from the zenith, your data suffer from atmospheric dispersion - the star is smeared into a little spectrum in a direction perpendicular to the horizon. You can capture all the wavelengths in the slit by orienting the slit perpendicular to the horizon. The position angle of an arc connecting a given point to the zenith is called the *parallactic angle*, because it's (anti)parallel to the direction of topocentric parallax displacements. Ordinarily, with the roator angle at zero the MDM spectrographs are oriented with their slits north-south, so that they're on the parallactic angle for any object crossing the meridian. Once you're far away from the meridian, you want to rotate the slit to the parallactic angle, but keep the rotator angle within +/-90 degrees. Because the slit is indifferent to 180-degree rotations, but the rotator isn't, the "slit angle" is the rotator angle which, for the present position of the telescope, will put the slit on the parallactic angle and keep the rotator within its travel. For instance, if the parallactic angle is -150 degrees, the "slit angle" will be +30 degrees. It's important not to interpret the "slit angle" as an actual readout of the rotator position, which is elsewhere on the display.

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About the MIS

All the commonly used instruments *except* the MDM 8k camera are mounted on an adapter called the MIS (Multiple Instrument System). This provides a number of commonly-needed utilities. Some useful diagrams can be found in the manual.

There are three parts to the MIS. Working downward from the telescope they are

The finder unit:

> This is a gold-anodized box about two feet square and 10 inches deep. It contains a large diagonal "finder mirror" which can slide in to divert the beam to a TV camera to view the surroundings. This TV is now seldom (if ever) used. However, the finder unit also houses a set of *comparison lamps* - an incandescent flat bulb, and Ne, Hg, Ar, and Xe discharge lamps - for calibrating spectra. The lamps shine off the back of the finder mirror, and the optics are arranged so that they provide an approximate f/7.5 beam to match the telescope. Note that you can either see comparison lamps or the sky, but not both at the same time, as they call for different positions of the finder mirror.

The guider unit:

> This is about 5 inches deep; it bolts to the back of the finder unit. It has a pickoff mirror which feeds optics leading to another TV camera. The pickoff mirror can be moved around on a precision stage, which I'll call the guide probe. The TV fed from this mirror is used for offset guiding; one finds a guide star by moving the guide probe, and then starts the autoguider to keep the telescope locked in position. At one position of the stage, the TV looks into a *slit-viewing microscope*, which is mounted at the end of a push rod. If you're doing slit spectroscopy, the staff will push the slit-viewing optics into place as part of the setup procedure. If you're working direct, the slit viewing optics should be retracted. The guider TV has a fairly small field (like an arcminute) The Ohio State CCDS has its own slit-viewing arrangement.

The filter wheel:

> The filter wheel is only used for direct imaging with the MDM facility CCD cameras. There are two wheels, one of which takes 2-inch filters and the other 4-inch filters. As of this writing the 4-inch filter wheel is not always working, but the 2-inch filters vignette the 2048^2 SITe chip to about 1600^2.

The MIS is operated using the xmis program on chichon. This issues commands to the MIS control computer, which is an ancient piece of equipment residing in the computer room racks. The controls are fairly straightforward to operate. There are a number of preset positions for the guide stage (slit, center, etc). You can also type in an X or Y coordinate for the guide stage and hit return to send them; an indicator blinks red while the stage is moving, then stops blinking and shows the new position when it gets there. You can also get relative steps using the "Delta X" or "Delta Y" fields. Other buttons or menus allow you to turn comparison lamps on or off, move the find/guide mirror in or out, or focus the finder camera.

There are a number of things to be aware of when using the guide probe.

1. If you're taking direct pictures, *there's nothing to stop you from blocking the telescope beam with the guide probe*. You *must* keep the guide probe away from the image area! There's a very confusing chart in the manual about this, but a rule of thumb is that if you keep the X coordinate less than a few thousand you'll be OK. If you have a cloudy night you might want to experiment by taking dome flats and moving the guide probe around until you can see it when you divide one picture by another - I've never mapped out the "safe" area myself, and someone should do it.
2. The guide probe camera needs to be focused so that when the telescope is in focus, the guide probe is also. The guide probe focus is controlled by a switch on a little box a couple inches square. If you're doing spectroscopy, and guiding off the slit jaws, you focus the guide camera during spectrograph setup, by looking at the slit jaws illuminated by a flat lamp (you'll need the TV gain way down), and focusing the guide probe until the slit looks as sharp as possible. Then when you get a star on the slit jaws, you simply focus the telescope until the star looks as good as you can get it. The slit jaws are in focus in the TV, and the star is in focus in the TV, so therefore the star is in focus on the slit jaws, which is what you want. In direct work, you focus the telescope on the CCD somehow (classical step 'n shoot focus test, or shutterless video if it's available for your chip and you're brave), then find a guide star and focus the guide probe on it.

   > NOTE: the focus in the slit viewing microscope is way different from the focus when the guide probe is looking up into the telescope as for offset guiding. This means that it's impractical in spectroscopy to park a star on the slit, then hunt for an offset guide star; by the time you've found a guide star and refocused the guider, the telescope has drifted enough that you can't be sure your program star is still in the slit. The OSU CCDS solves this problem by having a separate slit-viewing camera of its own, freeing the MIS guide TV for what it does best, namely offset guiding.

3. If the guide probe is driven past the end of its travel, it loses track of where it is. The probe can be reset by selecting INITIALIZE in xmis, which drives the probe back to its zero position and resets the counters. This takes a couple of minutes at the most.
4. The guide probe travel is larger than the unvignetted field of the telescope. You'll find that you can't see anything at Y<2000 or so, for example.

I find a good strategy for finding guide stars for direct work is as follows (units used here for X-Y are the default, raw counts; you can make them arcsec or mm instead)

1. Center up on the object
2. Be sure gain is up on the guide TV
3. set the guide probe to X = 0, Y = 2000
4. set Delta-Y to 1000
5. repeatedly hit carriage return and watch the TV to look for guide stars
6. stop when Y = 15000 or so (I think I remember the numbers, but I'm not certain).
7. At the top of the Y travel, set X = 1000 and Delta-Y = -1000, then step back down ...

and so on, raster scanning until you have a guide star.

In principle you can scan across the low Y range and up the far side of X without vignetting the chip, but this is seldom necessary. See the wacky diagram in the official telescope manual if you need to do this.

In very sparse high-latitude fields you may have trouble finding anything to guide on. I have an experimental program which predicts guider X-Y coordinates for USNO A2.0 stars around the field, so in principle you can select them ahead of time (for this to work, you mustn't have corrupted the guide probe coordinates by driving the stage out of bounds). The program isn't ready for prime time but may be helpful; if you'd like to try it, please contact me (john.thorstensen@dartmouth.edu). Computer gurus might wish to work on the program, for instance automating the web queries so it can run a batch of fields in background, or adapting it to run from a local copy of the USNO A2.0 (9 Gbyte!). Again, contact me if interested.

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About the autoguiders

The autoguider programs reside in a big old Gateway 486 PC which sits in the control room. There are two distinct programs, namely

The "New" or "Seitzer" guider (TVGUIDER)

> This is named after Pat Seitzer, who engineered it. In this guider, the video signal comes right into the PC where it's averaged on a board. You put a little box around the guide star, adjust a few things, and start the guider. It works really well for offset guiding - there are a bunch of things you can tweak, but you generally don't have to do much. Pat has also written a very user-friendly manual, which you should review before using it.

The "Old" or "DTI" guider (PCGUIDER)

> This uses the old cream-colored Digital Television Imagery ("DTI") box to integrate the signal. This integrated signal is fed into the PC, which then generates a guide signal using a program originally written by Mark Metzger and later tweaked slightly by myself. This program does not offset guide nearly so well - there are a large number of adjustable parameters and it can take some time to get things right. I wrote a manual for this guider which is quite complete, so you should be able to get it to work.

The Seitzer guider program works only with the integrator in the PC, and has nothing to do with the old DTI integrator. The program which takes its information from the old DTI integrator knows nothing about the integrator in the PC. The two pieces of software are designed for mutually exclusive integrators. Therefore, switching between the two guider programs involves plugging and unplugging cables, and starting a different program in the PC. The two PC programs have confusingly similar names (TVGUIDER = the new, Seitzer guider, while PCGUIDER = the old, DTI guider), but reside in different directories. Check the relevant guider manual for the right command.

The Seitzer guider is much preferable for direct work, but the DTI guider has compelling advantages for spectroscopic work (except with CCDS, which does things right). Most importantly, *the Seitzer guider cannot display an integrated image and guide at the same time*. Furthermore, the integrated images in the Seitzer guider aren't as smooth or as deep as those in the DTI. If it's important to see and guide on faint objects on the slit jaws, the DTI rules. As noted earlier, it would be better if there were a separate camera to view the slit jaws (as in CCDS), freeing the guide probe to roam around and guide the telescope with the Seitzer guider, but that's life.

Some TIFKAM observers have noted a way in which a subtle difference between the DTI and the Seitzer guider can be important. When the DTI-based program starts guiding, it notes the position of the star in its little box, then tries to hold the telescope exactly on its initial position. The Seitzer guider, on the other hand, tries to keep the star at the exact center of the little box, even if it didn't start out right at the center. The steps by which one moves the little box on the TV amount to a substantial fraction of an arcsecond; with a 1/2 arcsec slit, you can lose much of your flux just because of this silly digitization problem.

The DTI integrates with a "leaky memory", which gradually forgets the oldest signals; the image changes continuously, unlike the Seitzer guider, in which the new image appears abruptly. This can cause headaches after hours of staring.

There's often a lot of confusion about how to set the adjustable parameters of the guiders in various situations. TVGUIDER (the Seitzer program) wakes up with good parameters for direct imaging, and the manual should be helpful for fine adjustments. PCGUIDER (the DTI) has a menu of defaults for different setups, which should at least get the parity and rotation right. You may want to play with the guide rates (which default to be too small, corresponding to too-aggressive guiding), and the refresh rate and number of frames averaged (which will depend in part on how long your integration is on the DTI). A good way to test any guider is to get it going on a fairly decent star, push a guide button to throw the telescope off, and watch what happens -- it should come back fairly quickly. If it goes off the wrong way, or overshoots, something is wrong and you have to mess with the parameters.

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Some advice about CCDCOM

The standard old MDM CCDs are run by CCDCOM. The Ohio State instruments CCDS and TIFKAM are run using an entirely separate progam called Prospero, and the MDM 8K camera uses yet another control program, on a different set of computers.

CCDCOM has its own manual, which I am not repeating here. The purpose of this chapter is to draw attention to some features which are useful, and a hidden gotcha or two.

One of CCDCOM's most useful commands is source, which takes as an argument the name of a file, by default in the directory from which CCDCOM was launched. This causes the commands stored in the specified file to be executed by CCDCOM. Thus if you have a complicated set of repetitive actions, you can simply edit them into a file (called foo, let's say), and type

```
source foo
```

to execute the commands. Here are some ways you can use this to make your life much easier.

First, the readout format of the chip is set by the sf ("set format") command, which is followed by a bunch of numbers describing how the chip is to be binned and which columns and rows are to be read. If you've set up to read a subset of the chip (as for spectroscopy, say), you'll want edit up a little one-line file like

```
sf 2 2 300 400 500 600 700 32
```

or whatever the numbers are, so that if the camera has to be restarted you can quickly *and accurately* reproduce the settings. If you're off by one column, your flatfields don't work!

The source command can be very helpful in direct work, too. The read time of a big chip can be very considerable, so sometimes it's useful to read only a subarray. I like to set up files bigform and smallform, which are 2048^2 and 1024^2, so I can switch quickly. I also like to have a findform, which is the central 1024^2 binned 2x2, to give a very short read time useful for verifying the centering. You can nest source commands (a source command can occur in a file you're going to source), so I like to have a command which moves to focus mode, sets the chip format to small, changes the file prefix to something like "scratch", turns off clearing of the chip, and so on and so on, and then another command which goes back to full size, object mode, clearing the chip, and recording the data. Commands like this save a lot of time and prevent a lot of errors.

Here's another application. As a radial-velocity spectroscopist I must keep very close track of the wavelength calibration, which means taking comparison spectra before and after every sequence of exposures. The comparison lamp set at MDM is pretty poor down in the blue. There's a Hg lamp which has some very important bright lines, but there's a desert between 4358 and 5461. Xenon has some nice lines there, but the Xe lamp at MDM is extremely faint compared to the Hg. Furthermore, the Hg lamp has a long warm-up time, like 60 sec.

To get good comparison lamps every time, I combine the source mechanism with the tel command, which can command the telescope and MIS. Using a source'd file, I turn on the lamps to warm up, move the guider mirror away from the microscope to avoid frying the TV, move the find/guide mirror into the beam to reflect the comparison light down into the instrument, wait a little while with the tel sleep command, set the CCD to focus mode to get a multiple exposure, clear the chip, take a 0.1 sec exposure to get the bright Hg and Ne lamps, turn off the bright lamps, expose again for 60 sec to get the Xe, then turn off the lamps, read the chip, move the mirrors back into place, and reset CCDCOM into object mode to take real data. This is pretty error-prone, not to mention very labor-intensive, if you do it manually.

> *A word of warning:* I've had troubles driving the filter wheel with the CCDCOM tel mechanism. Better run it by hand with xmis.

You can interrupt CCD exposures by typing Ctrl+C, which in case you've been living in a cave for the last 20 years means holding down the Ctrl and C keys simultaneously. Once the exposure is stopped you can adjust such things as the name of the object, the exposure time, and so on. As for the exposure itself, you have three choices:

1. go <n> - continue the exposures, optionally including the number of exposures to do
2. rc - read the ccd and store the data.
3. cl - clear the chip, throw away the exposure so far.

Note the little gotcha in the go option: if you've started a sequence of (say) three exposures, and interrupt the second one, then typing go only starts a single exposure; you stop at two! To restart the sequence you'd need to type go 4 in this instance.

When you're taking sky flats, especially, the istat command is paramount. It does some quick statistics on the last image taken. With this you can see if the exposure level is correct. Ideally you want between 10K and 30K counts.

Note the existence of the "IRAF" flag, which now defaults to "on". This writes the images (in FITS format) in such a way that IRAF properly understands them as unsigned short integers (0 to 65535). The digitizer uses all 16 bits without wasting a bit on the sign, since the raw numbers are all positive.

CCDCOM does not display images or do any analysis (though the istat command can be used to check mean values). To display images, ximtool and IRAF are available (and they work directly on FITS images, of course.). Xvista is also available.

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