Observing Variable White Dwarfs with Argos/Raptor

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Contents

*This document was originally written by Fergal Mullally but is currently being maintained by JJ Hermes. Another robust manual for using Argos is maintained by Rob Robinson.

1 What's new

1.1 Version Update: 16 Apr 2012

This manual has a new keeper. Send any changes or corrections to jjhermes [at] astro.as.utexas.edu

Changes to reflect the latest version of the data acquisition software, Quilt 13.00, as well as the new hoth and opus systems. This manual is now essentially an updated hybrid between Fergal Mullally's manual and Dean Chandler & Brad Walter's updates.

2 Conventions

2.1 Fonts

1. Names of computers and programs are written in sans sarif.

2. Commands to be typed are written in `typewriter typeface`.

2.2 Computers

Opus Data acquisition computer, attached to camera and GPS box. Usually has the hostname opus.

Hoth Data analysis computer (and web browser). Hostname usually hoth.

Luke Dome camera controlling computer. Hostname usually lukem.

Nereid Observatory Sun which stores night report software, skycalc, etc. Hostname usually nereid.

Prometheus Telescope pointing and tracking control computer. Hostname usually prometheus.

Rocky Austin-based data archive. Hostname usually rocky.

2.3 Positions

Service HA $= 0^h0^m$, $\delta =$ as far north as you can go (usually $\delta \approx +68°$, once you've crossed $\delta = +90°$, is sufficient). The telescope is lying horizontal and prime focus can be accessed from the service position. Shortly before the telescope reaches service, an alarm will sound and the slew motor will cut out. Push the small black button on the bottom right of the console to acknowledge the alarm and proceed carefully. **You must be within 1^m of HA $= 0^h0^m$ or you risk collision of the telescope with the north pier.**

Stow HA $= 0^h0^m$, $\delta = -20°$. Where the telescope is parked at the end of the night.

Zenith HA $= 0^h0^m$, $\delta = +31°$. Pointing straight up.

Flat field HA $= 0^h0^m$, $\delta = -40°$. When pointing at the flat field position, keep the dome pointed east, so the white square is in front of the telescope.

3 Warnings

NEVER rely on safety margins posted in the control room or built into the telescope. Argos extends farther beyond the front of the telescope than was considered when these margins were formulated.

Observing Conditions

Always close the dome when required by weather. The requirements are listed online and on a document, "Closing Because of Weather," which is on the bulletin board in the control room. When humidity is high, go out onto the catwalk and close if the dome shutters are dripping water. When dust is high, go out onto the catwalk and confirm dust with a flashlight. If you are in doubt about whether to close, don't hesitate to consult with more experienced operators on other telescopes (for the 107” control room, call 106). Just remember that the responsibility for closing is ultimately yours.

The Dome

The “pulpit” structure of the dome can cause considerable damage and possible injury. Be especially careful when using the telescope near the horizon. Inexperienced users should not put the telescope near the horizon unless accompanied by an experienced user, especially when pointing east. Be aware of its relation to the pulpit structure and associated pulleys. Never place the telescope between the pulpits with Argos on it. Wind can catch a dome shutter and move the dome unexpectedly.

Observe the following precautions:

1. Never move the dome while anyone is on the dome floor walkway
2. Never move the dome while the telescope is in the service position
3. Never place the telescope between the pulpits
4. Watch out for the pulleys above the pulpits — they can collide with the camera controller
5. Always make sure the interior catwalk (the grey metal walkway all around the inside of the dome) is clear of any obstructions — the platform underneath the dome slit will eventually collide with any obstructions, probably destroying whatever the obstruction was.

Telescope service position

To avoid **collision** with the north pier, the telescope must be within one minute of zero hour angle when sending the telescope to the service position. Shortly before the telescope reaches service position, an alarm will sound and the slew motor will cut out, preventing the telescope from colliding with railing of the dome floor walkway. You may turn off the alarm by pushing the small black reset button on the bottom right of the console. **Note: Pushing this button overrides the safety stop.** When you move the telescope away from the service position and you have hit the override, you must search south before you may slew.

Telescope flat field position

Use great care not to go south of the flat field position ($\delta = -40°$), even by a degree. There is no safety cutoff to prevent the telescope from colliding with the setting circle cover.

Shutting down systems

1. **Always power off the camera using the switch at the electronics box**. This is the only safe way to power down. If power to the camera is interrupted in any other way (unplugging the electronics box, removing the camera cable, etc.) the camera may be destroyed. You should power down the controller every night.
2. Always power down and unplug the computer Luke before removing the cable to the dome camera. Failure to do this will destroy the dome camera.
3. It is recommended that you shut down `hoth` before shutting down `opus`. Otherwise the NFS server might hang and `hoth` won’t shutdown correctly.

4. Thunderstorms are common at McDonald, especially during the summer, and frequently cause extended power failures. If you expect a thunderstorm, you should consider turning off the Argos controller box. See the Troubleshooting section at the end of this manual.

4 Setting up on the first afternoon

As a facility instrument, nowadays Argos is set up by the observatory staff. Everything should be ready for you. If something is amiss, contact David Doss. If something isn't set up, what follows are some steps you can take to correct the situation. If things are already setup, skip to § **4.4**.

The computers prometheus and nereid, require an account. Contact M. Frueh or J. Kuehne for assistance.

4.1 Finding things

When you arrive you should find the CCD camera, the controller box, and a box with Allen keys and the BG40 filter sitting on a table in the control room. If things are not readily present, they may be in Ed Nather's old locker. It's usually unlocked, but if it's locked, the combination is Right 16, Left 22, Right 16. It's a tricky lock, so it might take you a few attempts to get it open.

4.1.1 Cleaning CCD window

Visually check the CCD window to make sure it is clean. If you see any smudges, dirt or dust you need to clean it. To do so,

1. Unscrew the dome camera and its mount from the CCD camera case.
2. Unscrew the camera from the camera plate.
3. Unscrew the top of the camera case. Remember the orientation of the top with respect to the rest of the case.
4. Wipe the window clean with a lint-free tissue.
5. Replace the top of the case, in the same orientation as you found it.
6. Replace the camera plate. The number '1' etched on the camera plate should be to the upper right (and on the camera case, the arrow should be pointing up).
7. Replace the dome camera, with the lens pointing in the opposite direction as the ccd camera.

4.2 Attaching things

1. The camera plate is attached to the Argos mount with two fixing pins and 4 captive screws. First slide the camera plate (with the camera already attached) onto the fixing pins. Take care not to do this at an angle as it tends to get stuck. You may need to wiggle it into position, so the camera plate is sitting flat on the mount. Once in position, tighten the captive screws.
2. The Electronics box is screwed into a support strut projecting from the left side of the top of the telescope. It is held in by 10 screws. If you look at the support strut you will see many more than 10 screw holes. Attach the box so it is as far away from the primary mirror as possible. The on switch should face the primary mirror, the cable sockets should face the sky.

3. Argos uses a Schott BG40 blue-pass filter to help reduce noise from scattered light. This is placed on the filter slide which slides into the mount. There is a small piece which must be unscrewed first to allow the filter slide in and to stop the filter falling out during the night. Take care to touch the filter as little as possible, and then only on the sides. There are two positions on the filter slide. Ensure that you put the filter in the position so that when the slide is pushed fully in, the filter is in the light path, and the slide pulled out, the filter is out of the light path.
   slide in = filter in
   slide out = filter out

4. The power and signal cables should be coiled up on the dome floor on the west side. Pass these over the platform railing, over the strut joining the telescope to the dec wheel that is closest to the primary mirror, and up the tube of the telescope. The top half of the telescope consists of heavy and light struts. Go over the light struts and under the heavy ones.

   Connect the high speed data cable to the 15 pin slot and the co-ax cable to the EXT SYNC connection (second from left of the four co-ax connections). Plug in the power cable.

5. Secure loose cables with cable ties where necessary.

6. Attach the grey camera cable to the CCD camera and the controller box.

7. Clean up any loose tools, and stow the ladder. Make sure the dome will not crash into anything when it rotates.

4.3 Turning on Dry Nitrogen

Argos uses a dry nitrogen feed to prevent condensation forming on the chip, even in conditions of high humidity. The air supply should be turned on at the start of the run, and left on until the run is over. If the nitrogen isn't used for Argos it will be vented into the atmosphere anyway. The valve is located on the west wall of the dome. Turn the knob until the small ball rises to the number 1 position, corresponding to 20 psi at a flow rate of $\sim 1/2$ SCFH (standard cubic feet per hour).

4.4 Setting up the computers

4.4.1 Setting up opus

Data is taken on opus. With so much data, it needs to be organized in a simple way. Every observing run is named after the month and year it *started*. So an observing run which started on the 28^{th} February 2005 would be called feb05 (lowercase). If two observing runs start in the same month (a blue month), the first run is called feb05a and the second is feb05b. It is the observer's job to create these directories on opus, but the Quilt program will create the directories for the individual visits to each object.

1. opus should have been left on since the last run. If it wasn't, turn it on.

2. If you have just turned on the machine, log in as ccd. Check that the /data1 disk is cross-mounted.[1]

[1] If it is not, open an xterm and su to root. Type
```
exportfs
/etc/init.d/nfs start
```
Then log root out with exit. The list of allowed NFS clients is stored in /etc/exportfs

3. Check that the ntp ("network time protocol") daemon is running correctly by executing the command:
`/usr/sbin/ntpq -p`

4. `cd /data1/opus; mkdir feb05`

5. Check that there is enough space (at least 2 GB per night) on /data1 with the `df -h` command. If there isn't, delete the oldest run present. Before you do, check that the data is both backed up to rocky's raid array and backed up on an external hard drive.

6. `cd ~/log`. Edit the perl script logentry `pico logentry`. Look for first line where the variable `$homedir` is declared, and change that to the path of the data (/data1/opus/feb05/).

7. In the same directory edit the file template.log, changing the month of the run to February 2005 and the list of observers. For more information on the logentry program, consult its readme file.

8. Start q13 (`cd ~/quilt/; q13`). You can also double-click the Quilt 13 icon on the desktop. Wait until an image pops up in the ds9 window and wait again until you can clearly see the image updating. If this doesn't happen, consult the troubleshooting section of this document.

9. Change q13's path to where you want the data stored: In the setmode window type `/data1/opus/feb05/&`

4.4.2 Setting up hoth

1. hoth should have been left on since the last run. If not, turn it on.

2. Check that the opus disk is mounted with `df -h`. Try copying some files to make sure everything is mounted properly.[2]

3. Now that opus is mounted on hoth, make sure you shutdown hoth before shutting down opus

4. The morning after program is responsible for checking the accuracy of the log and the timings of the previous night's data, as well as extracting light curves, and backing up the data to the remote machine. First it needs to be told where to find the data. `cd ~/bin/mornafter; vi mornafter.pl`. Change the variable `$datadir = "/data1/opus/feb05"`. Change the backup directory to `$backup = ''rocky.as.utexas.edu:/data4/rocky/smaug/feb05''` and edit the array of users who will receive an email for the minion every morning summarising the night's observing. Remember to preceed every @ sign with a \@, eg "dew\@rocky", "fergal\@astro"...)

5. Log onto rocky as ccd and create the directory ~/smaug/feb05 (again, replacing feb05 with the month of your run).

6. Open track82 on hoth so you can control tracking rates more easily:
`cd /opt/local/bin`
`iTrack (note the capital T)`

[2]If not, log in as root and type `mount opus:/data1/opus/ /data1/opus`. Exit root immediately.

4.4.3 Setting up luke

Luke is much easier to set up. Plug it in and turn it on (you did unplug it before attaching the cable to the dome camera, right?). Log in to luke as ccd with the usual password, and type in the following two commands.

```
./load
./idcam
```

load will prompt you for ccd's password. You only need to type load the first time you log in after booting. idcam is the program which runs the camera and displays the images. (It is also possible to log into luke from hoth and execute these commands, instead of displaying the image on luke's screen.)

4.4.4 Setting up nereid

How many computers does one observer need? Nereid is the observatory computer (it is common property, not specific to Argos) and is useful for checking the moon phase and updates the observing log. When you first log in, right-click on the desktop to reveal the Workspace Menu. Select "Hosts" and click on "Terminal Console" to open a console window. There, you can run several useful programs:

1. skycalc is useful in determining the time of sunrise, sunset, moonrise, moonset, and the phase of the moon
2. xreport & opens the GUI to fill out the Night Report
3. wxcon is a dinky weather monitor

4.4.5 Setting up prometheus

Login to prometheus using your own login and password. Type startx to open the Linux operating system and right-click on the desktop to open a terminal window. Once there, open the prime focus pointing program cosmo prime. You can also start the tracking software by typing track82.

4.4.6 Setting up rocky

Rocky is the data archive server back in Austin. The log in is ccd, with the usual password. In the data directory (cd ~/smaug), create a directory for this observing run (e.g. feb05). You probably already did this in the step in § **4.4.2**.

5 Start of night

Try to get up to the dome after dinner at least 30-45 minutes before sunset. If you haven't already done so, check the dry nitrogen (§ 4.3). Make sure that the filter is in the dark slide position and is blocking light. Check that opus appears to be working well, then start taking calibrations. Calibration frames are taken every night that data is taken (cloudy nights too) and are named according to the formula tddmmmn, where t is the type of calibration file (b=bias, d=dark, f=flat), dd is the day of the month, mmm is the name of the month and n is the exposure time. For example, d11dec15 (note lowercase) are dark frames taken on the 11^{th} of December that have 15 second integration times. **The date you want to use is the UT date of observations.**

5.1 Using Quilt 13

Q13 can be started either by double-clicking on the icon on the desktop on `opus` or executing the command ∼`/quilt/runmode`. A total of 6 windows will pop up. The main one is called "Quilt 13.00". Enter run details in the left panel, and review instrument status on the right panel. Caution: Details entered in the text boxes are not processed until you click on one of the other text boxes.

Before you begin taking calibration frames, it's a good idea to make sure that the camera is properly cooled. The camera temperature should be between -40.0 and -40.5 degrees. If the controller box was recently turned off, it will take about 10 minutes to cool from room temperature. Check that the GPS is "locked" and that the GPS offset is no more than ±30 ms. The program status should be "idling."

5.2 Taking biases

Bias frames are zero second exposures that measure the DC offset of the voltages that are read out from the chip. These frames aren't particularly useful to us because the bias level on Argos fluctuates significantly over the course of the night, but we take them for posterity's sake.

1. Start q13 if it's not already running
2. Set the run name to bddmmm; eg if today is the 30^{th} February, the run name is b30feb. Because biases are zero-second exposures, we don't specify an exposure time.
3. Set object to "bias"
4. For consistency, set the exposure time to 1. Quilt will recognize that these exposures are zero seconds.
5. Take 30 frames by **right clicking** on the go button, and typing 30 into the pop-up window.

5.3 Taking darks

Take a set of dark frames at the exposure length of your flat field frames (usually 10 seconds) and a set of dark frames at each exposure time used for your science frames during the night. For consistency's sake, take a set of dark frames at 5, 10 and 15 seconds every night, regardless of whether you take any science frames at those exposures. A set of frames consists of 30 exposures.

1. Although this should be true from the night before, make sure that the filter slide is pushed all the way in, such that the opaque circle is blocking light from the CCD.
2. Set the run name to dddmmm5; e.g. if today is the 30^{th} February, the run name is d30feb5
3. Set object to "dark"
4. Set the exposure time to 5
5. Take 30 frames
6. Repeat procedure for 10 second darks (d30feb10)
7. Repeat for 15 second darks (d30feb15)
8. Repeat for 30 second darks (d30feb30) if you anticipate observing a very faint target

9. If you expect to take observations at a different exposure time, repeat procedure for each non-standard exposure time

5.4 Taking flats

Turn on the flat field lamp:

1. Ensure that the dial on the flat field lamp variac is turned all the way to the left (off position)
2. Switch on the lamp using the left switch (flip up)
3. *Slowly* turn the dial clockwise until the voltage reads about 31 V

Move the telescope into position:

1. Insert the filter slide so that the dark slide is now pushed out of the way.[3]
2. Bring the telescope south to the flat field position (to HA = 0^h0^m, δ = -40°). The dome should be pointed due east.
3. Turn off all lights in the dome besides the flat field lamp. Open the mirror cover.

Check that the average number of counts per pixel in a 10 second exposure is between 20,000-30,000[4]. If not, adjust the voltage on the lamp. Record 30 flat frames.

1. Set the run name to fddmmm10, e.g. if today is the 30^{th} February, the run names is f30feb10
2. Set object to "flat"
3. Set the exposure time to 10
4. Take 30 frames

It is generally not a good idea to turn on the dome floods while preparing to take flats. On some CCDs (and likely for Argos), this can cause hystereses, where the recorded counts are unnaturally high for some time after being exposed to bright light.

When finished turn off the flat field lamp.

1. Turn the voltage slowly down to zero volts.
2. Flick the power switch down to off.

[3]If the telescope is stowed, the quickest way to insert the filter slide is to bring the telescope to (HA = 0^h0^m, δ = -6°), climb up the catwalk, lean out and pull the filter into position. Alternatively, bring the telescope to the service position. Note: Inserting the filter slide amounts to pulling the bar all of the way out. The blue filter circle should be over the CCD.

[4]Keep the signal below 50,000 ADU/pixel to avoid non-linearities or saturation.

5.5 Opening the dome

1. The dome should be opened at crossover, as soon as the outside temperature matches the dome temperature, weather permitting.

2. Open the dome slit and raise the upper wind curtain fully. Start opening the dome slit, and if you don't hear anything falling after about 5-10 seconds, start raising the wind curtain.

3. The dome slit leaks, and if it has been raining since the telescope was last used a considerable amount of water will collect in the wind curtains. **If it has rained recently, do not point the telescope straight up while raising the wind curtains.**

4. Open the dome doors to improve ventilation.

5. Point the telescope. The best thing to do is to point the dome and telescope down wind. Typically you can point in the general direction of your first object.

6. Turn on the tracking. If it is winter, it may take one minute for the tracking to kick in, as it is warming up.

6 Observing

This section details the procedure for setting up on the first object of your run. Although the process is similar for every other object you will observe, there are many steps that you don't need to take every time.

6.1 Zeroing the telescope

This section is optional, and usually unnecessary. If you experience persistent difficulty pointing the telescope to the correct position, try this step.

1. Log into prometheus and load the coordinate precession program by typing `cosmo prime`

2. Find a bright object ($\approx 6^{th}$ mag or brighter) which is easy to recognize. A copy of the bright star catalogue is available in the control room

3. Find the flexed coords of the star using the p command on prometheus (`p hh mm ss +dd mm ss`)

4. Move the telescope to the flexed position

5. Using the hand paddle, move the telescope so the bright star is in the center of the frame

6. On prometheus type `p z`. Repeat a couple of times because sometimes it doesn't catch

6.2 Pointing

1. Get the coordinates of your first object (if it's a common object, you may be able to get it's coordinates from the finderchart stored at hoth:~ccd/findercharts).

2. Precess the coords using the `p` command on prometheus: p hrs mins secs degrees mins sec (e.g `p 22 14 05 -00 25 01`). The coordinates to point the telescope at are the flexed coordinates. Also note down the tracking deviations.

3. **Take care when moving the telescope, making sure not to collide either end of the telescope with any hard object**
4. Turn on the tracking. This is done using the track82 program on prometheus (prometheus has a console on the dome floor, and another in the control room).
5. When you've pointed the telescope, remember to set the tracking deviation rates.
6. Find your object and a good reference star on the q13 chip image. Try to keep stars you intend to take data of away from the edges of the chip and any bad pixels

6.3 Starting the observation

All of this section is performed on opus.

1. Set the run name by clicking Next. This should return a value like A2100 (although we are now technically using the Raptor camera, we will continue the A naming convention).
2. Set the object name
3. Set the exposure time
4. Mark stars using `mark`. When finished, hit [ENTER] or click the `mark` button again.
5. Wait until q13 displays the status "Idling." Then start the run using `Go`. This will take images until the disk gets full. The command `Stop`, stops the data collection and `Abort` stops recording and deletes all data collected on this run so far. Don't get `Stop` and `Abort` confused.
6. In a seperate xterm window on opus, `cd ~ccd/log`
7. Start a new log entry by typing logentry run, e.g `logentry A0666`
8. If this is your first run of the night, you will be prompted for nightly information (sunrise, moonset, etc.). You can find most of this data using nereid's skycalc program. When you have entered the nightly information, type [Ctrl]+[X] to enter the main log.
9. Fill in each of the fields in the main log. The date field should be entered as 2004-12-31 (yyyy-mm-dd) and the time as hh:mm:ss. At the end of the night, a computer program will check these values against the headers of the fits files saved by the computer and complain if they don't agree. It is not a major problem if the format of these fields is wrong, but it is a major source of confusion if the information does not agree with the fits headers.
10. Perform a timecheck by comparing the time displayed by opus with the observatory GPS clock. It is also useful to check the UTC time on the hand paddle in the control room with the UTC time in q13. Note when you performed a timecheck by entering "`Timecheck (hh:mm:ss) OK`" into the log.
11. Mention why you are observing this object, if you expect to see anything unusual (e.g an eclipse, or if this is a candidate pulsator) and any other information that may help a future astronomer understand why you were using your time the way you did. At the end of the run mention why you are stopping (object too low, more interesting object rising, have enough data for what you need, etc.). This simple step is invaluable for people browsing the Argos archive at a later date.

6.4 On-line analysis (The Blind Monkey routine)

Q13 performs aperture photometry on the target star that is acceptable in moderate to good observing conditions. Historically, however, this was not the case, and a large collection of scripts built up over the years on hoth perform this function. You are strongly encouraged to use these scripts because a) they are of better quality than those produced by Quilt (see § 8.2.1), and b) the proper, calibrated reductions assume that they will be run.

Unfortunately, the on-line analysis currently involves using IRAF. All the following steps are performed on hoth. You should do an on-line analysis even if you don't think you want to see the data, as the next day analysis requires one of the files you will produce here in order to complete its task. On hoth, open a terminal window and type the following commands.

- `xterm: ds9 &`
- `xterm: xgterm &` (This opens an xgterm window for the IRAF scripts by calling the routine ~/bin/xgterm.fedora. Commands to be entered in this window are prefixed by `xgterm`).)
- `xgterm: cd ~ccd/hsp/ccd_hsp`
- `xgterm: cl`
- `xgterm: ccd_hsp`
- `xgterm: chdir /data1/opus/feb05/A0666` (updating for your month and run name)
- `xgterm: epar mark` (In the epar window, set fname to A0666.0001.fits, where you'll replace A0666 with your run name, press the down arrow, then type `:go` to execute.)[5]
- Highlight the ds9 window (careful if you have already done this once, it will prompt you for a change), move your mouse over the target star and type `w` then `r` (IRAF has a tendency to annoyingly highlight other windows for you instead). Reselect the ds9 window and press `w`.
- Move to the brightest reference star and type `wrw`.
- Repeat for other reference stars on the image. Err on the side of having too many reference stars instead of too little. You can always discard them later on. Avoid using as comparison stars those with peak counts above 50,000 ADU (the start of the non-linear regime), but otherwise, preferentially choose brighter stars. IRAF does have a tendency to crash if you choose more than 8 stars.
- In ds9 type `q` to quit,
- `xgterm: [ENTER]`
- `xgterm: :wq` (To write-out and quit the coordinates.)
- `xgterm: yes` (if you are happy)
- `xgterm: epar hsp_ol`

[5] To change a field in an epar window, use the up/down arrows to select the field and type. IRAF automatically overwrites the old value. If you make a mistake, hit [ENTER] and start again. IRAF has no delete key in these windows.

- `xgterm:` Change nome[6] to A0666.0001 and set the integration time, delta_t.[7]
- `xgterm:` Type `:go` to start the extraction.
- Open a new terminal window and type `cd ~ccd/splot/`
- Type `bmr /data1/opus/feb05/A0666`, adjusting for the path of your data. A pgplot window should pop-up showing a real-time Fourier transform of the target star's light curve and is updated every minute. You'll want to wait until hsp_ol has reduced at least 15 frames before starting this script, or it may fault.

6.5 While taking data

1. Keep an eye on the dome to make sure it isn't occulting the data
2. Watch the seeing, and if it degrades significantly try to improve the focus. This will often be unsuccessful because the problem is usually bad weather. Q13 attempts to untangle poor seeing from poor focus with the "Focus Index" indicator, but don't rely overly on this estimate.
3. Keep close watch on disk space on `opus:/data1`. Try to keep at least 10% free at all times.
4. Note any interesting, unusual or significant details in the log file. Prepend each note in the log with the number of the frame in which the log entry was made. Err on the side of writing too much, as this is the only source of information future users of the data will have. If you need convincing of this, take a look at the log for A0981 in jan05. The log excitedly mentions an eclipse that the observer could remember nothing about the day following the end of the run. We'll never know what happened. Some more explanation of what the object was and why it was being observed would have really helped.
5. Perform a timecheck at the start of every run, and every 2 to 3 hours afterward.
6. Watch the weather. On `hoth`, the command `wx` and `wx_gui` bring up command line, and graphical weather displays respectively. Links to satellite maps, radar etc. are bookmarked on `hoth`, but there's no substitute for going outside and looking.
7. Do what it takes to stay awake.

6.6 Changing targets

1. Choose a new target and find its precessed position before stopping the current run.
2. Stop the data acquisition by clicking Stop in the q13 window.
3. Enter the time of the end of the run in the log, and the number of frames observed. It is also often useful to mention why you stopped observing, this is often a mystery to others analyzing your data.

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[6] [name]

[7] There are lots of options for this package, but you won't need to fuss with the rest of them. If you'd like to have colored circles follow your stars, make sure `yes` to `tvmark`. You always want `red`, `display`, and `mark_int` to be `no`. The best method to follow the stars is to set `follow` to `previous`, and you should leave the internal radius and width of the sky annulus at 16 and 8, respectively. Finally, if the seeing is extremely bad and your star is bright, consider setting `aperture` to 8 or 10 to better your online reductions. Otherwise, 6 is a good default aperture.

4. Take a screen shot at the end of the run
5. Repeat the above steps, starting with pointing the telescope.
6. Stop IRAF's light curve extraction (hsp_o) by hitting [Ctrl]+[C] in the appropriate window.

7 End of night

1. You should stop taking data when the divided light curve in your on-line reductions shows a noticeable loss of quality. By this point you have gone beyond the point of taking usable data.
2. Sometime before this happens, fill out the Night Report on nereid (type `xreport &`). This is required of observers every night whether you take data or not, and the mountain staff get quite prickly if you forget to fill it in. Fill it in even if you spent the entire night down in TQ drinking beer. Don't mention that you were drinking beer. Just say it was cloudy or something.
3. Stop your run as described above in § 6.6.
4. **Stop the telescope from tracking.**
5. Close the dome doors, close the slit, lower the upper wind curtain to protect the telescope from rain, and close the mirror cover.
6. Make sure you've exited Quilt, take the telescope down to the service position, and power off the controller. Move the filter slide so the dark slide blocks the light path (filter out position).
7. Put the telescope in the stow position (HA = 0^h0^m, $\delta = -20°$) and point the dome east.
8. **Power off the telescope console.**
9. Start the data analysis and back-up on hoth by going to the directory hoth:bin/mornafter and typing `mornafter.pl 30feb`, or whatever date you used to name your calibrations. For example, for data taken on UT 30th February, you will have flat frames called f30feb10, so type `mornafter.pl 30feb`. This command will compare your log to the fits files, check for timing errors, flat-field and extract your data, produce light curves and back up the data to rocky for you. If the program encounters difficulty finding calibrations files it will warn you and allow you to quit. If you see no messages, hit [RETURN] and go to bed. See Mullally et al. (2005 ApJ 625:966) for a full description of the data reduction process.

8 Next day

The work never ends, does it?

8.1 The Minion

Mistakes are inevitable, and cause untold confusion at a later date. One way to reduce the confusion is to log everything unusual (and some mundane), explaining what you did and why. Often the mistakes are typographical, and the minion helps to spot these. The minion compares the common entries between the log and the headers of the fits files and alerts you to any typographical differences. Where the log and the fits headers are in disagreement, the offending entries must be corrected the next day.[8] You should receive an email from the minion every morning after you run the morning after script. If you don't, see § 4.4.2.

- Errors in the log can be easily corrected. However, make copious notes in the log about what changes were made and why.
- Errors in the fits headers (i.e the information entered in the setmode window of q13) are more difficult to fix. On `opus`, `cd` to the data directory and use the command `afedit`. For example, if you observed the star GD66 but mistakenly called it GD99, type `afedit OBJECT "GD66"`. The header will be changed for each fits file and copies of the original will be stored in a subdirectory. A readme file will be created, in which you should note what the error was, why it was made (e.g typographical error, same object name as the previous run, etc.) and what change was made.

Remember, that any files changed must be copied up to the backup machine. If the error is in the fits headers, backup the entire directory again.

8.2 Reducing data

With such large quantity of data being collected on a clear night, it is impossible for the human eye to examine everything. This unfortunately means that some interesting or important events will be missed, but has the advantage that all data is reduced in a consistent manner, warts and all. The tedious tasks of flat-fielding and performing aperture photometry on each image have been almost entirely automated (if you never do anything unexpected you will never have to worry about these steps), however, there are still a number of steps in the pipeline for which the human eye is required.

Argos uses IRAF's ccd_hsp package to produce light curves using a technique known as aperture photometry. The output of ccd_hsp has to be massaged slightly before being reduced. The following procedure is performed on `hoth`

1. Change to the directory containing your data.
2. If ccd_hsp was successful, you should see a number of files names a0666pr8., or some variant thereof. a0666 stands for the run name, while 8. refers to the size of the aperture used in reduction. Apertures will range in size from 3 to 14 pixels, in increments of 1 pixel.
3. First copy all files needed for reduction to a subdirectory red using the command `mvlc a0666`, where a0666 is the run name (note lowercase)
4. `cd red`
5. From each aperture file, extract out the photometry for the target star, `extractCh a0666`. The resultant file is called a0666.app
6. The optimal aperture size depends on the seeing during the run and the magnitude of the star. There is no algorithm in the world which can choose the aperture yielding the lowest scatter as quickly and easily as the human eye. Plotlcs converts the lightcurves to mean zero and plots them 3 to a page, allowing you to choose which aperture produces the lowest scatter. If you can't decide which of two or three light curves is the best, don't worry. If you can't see much difference, there isn't much difference. `plotlcs a0666.app`

[8] The minion is a strict grammarian, and will complain that 03:04:05 is different from 3:04:05 or 03 04 05. It is up to the observer to decide whether these differences are important enough to be changed.

Each aperture is listed in order. [Enter] cycles through the different aperture sizes. Use z and Z to zoom in on the graphs.

7. Create a Wqed file from this extraction. `lc2wqed ../A0666.0001.fits a0666pr12.` (if 12 is the best aperture). This creates a file called a0666.wq.

8. Your data is now ready for the Wqed data reduction program. Wqed comes with a detailed manual that should be available on hoth, but the following quick tutorial should be sufficient.

   (a) Start wqed by typing `wqed a0666.wq`. A window should pop up showing you your light curve. The white dots are the target star, the red dots are your first reference star.

   (b) Select the target star by typing [1]. Remove obviously bad points by typing [G] (for garbage) and selecting the region to delete.

   (c) Type [2] and repeat the process for the reference star. Unhappy with your choice? Hit [CTRL]+[U] to undo.

   (d) Select the target again and hit [/]. You can divide the target light curve by one or more reference stars by selecting the appropriate numbers.

   (e) Fit a second order polynomial to the divided light curve by typing [F] then [2].

   (f) Save your reduction by typing [SHIFT]+[W], then [E].

   (g) Type [Q] at any time to quit.

   (h) To create an FT of your output, try fitlc (`fitlc a0666.lc1`), or wqplot (`wqplot a0666.lc1`)

Type [?] to see a list of available commands, or consult the manual.

8.2.1 Don't use the Quilt reductions!

Reducing data is complicated, and the observer may be tempted to use the extracted light curve created by Quilt instead. This is strongly discouraged. Currently, there are two known flaws with the Quilt reduction. Firstly, the flat field algorithm is incorrectly implemented, and makes no use of bias or dark frames. Secondly, Quilt uses a variable aperture photometry routine, but does not perform an aperture correction. In conditions of variable seeing (so common at McDonald that it is frequently referred to as "McDonald-o-metric seeing"), the measured flux varies by different amounts for stars of different brightnesses. This introduces an artificial signal into your data.

8.3 Archiving your Reductions

It is possible that your data will be useful for something. It is also possible that your data will be useful for another, unintended reason. For this reason, it is important that there be an archive of observations that future researchers can refer to. If you ran the morning after script, your raw data will be copied to an archive disk in Austin. However, given the work involved in reducing raw data, it makes sense to archive the finished results as well.

Archiving your data is mandatory if you are part of the white dwarf group in Texas, but it is encouraged for other WD observers as well. If you used the morning after program, you must archive your reductions as well.

The reduction archive is stored on rocky.as.utexas.edu:~ccd/argosdata/obsrun/. Login as user ccd and create a new directory there for your observing run (using the same naming system described in § 4.4.1. Create a sub-directory for every run and upload the following files from each run: *.wq *.lc*

*.log. Don't upload any fits files, they are already backed-up. The prep command on hoth simplifies the uploading process.

```
cd /mnt/opus/feb05
prep
```

This will create directories containing the files you need to archive. Upload these to rocky using scp,

```
scp -rC a0666 rocky:argosdata/obsrun/feb05/
```

Then, for each run on rocky, create a quick look image of the data using `wqanal run -f`. A cron job will automatically find this image and post it on the archive's webpage.

8.4 Burning DVDs

With the new opus machine, burning DVDs has become GUI'd with the updated version of Linux. Simply move to /data1/opus/ in the File Browser, right click the folder of the observing run you wish to backup, and click on "Send To...". Send as: CD/DVD Creator and insert a blank DVD. Click Send and wait for your data to burn.

9 End of Run

- Ensure that the telescope is in stow position.
- Ensure that all your raw fits files, including your calibration files, have been backed up onto rocky.
- Ensure that your reduced data has been archived. If you haven't finished reducing it all, that's OK, but get it done as soon as possible.
- Tidy up the control room for the next observer.
- Log out of all machines. Make sure you shut down luke so the Observatory Support doesn't fry the dome camera.
- Go home. You've been here long enough.

10 Troubleshooting

10.1 q13 won't start

The principle reason q13 doesn't start is because the camera isn't turned on or properly connected. Bring the telescope down to service position and check that the controller box is turned on. If it is, turn it off and check that all cables are correctly and securely attached, especially the cabling to the camera head. Turn on the controller box and try again.

10.2 q13 hangs

This most often happens if you leave the program running during the day, for reasons that are buried deep in the code.[9]. First try to close the `commands` window by clicking on the `x` at top right. Then type `ps -u ccd`. Note the PIDs (1st column) of and programs called `q13`, `runmode`, `ds9A`, `xpans`, `setmode`, `camstat`. Kill each and all of these tasks using `kill -KILL PID`. Be sure to kill every instance, as the problem is often a halted program lurking in memory. Restart q13 normally.

10.3 q13 starts and quits immediately

This could be any number of things, but check to see that you have enough disk space left where you're putting your data. It could also be the symptom of a loose cable connection.

10.4 Images in q13 don't update

This is not necessarily a problem. If the integration time is short and much data has been acquired during a run, `opus` may have difficulty keeping up with the workload. To preserve data integrity, q13 first sacrifices updates to the ds9 window. If you wish to continue running without continuous ds9 image updates, you can view the occasional image on `hoth`.

Otherwise reboot `opus` while leaving the Argos camera turned on. If this does not work, the timing circuitry may have a problem. Perhaps the timing card (Asterix) has come loose from `opus`. (The timing card fits into LPT1 and has two co-ax cables coming out the back, one to the GPS box and the other to the controller box.) Check that the co-ax cable is plugged into the EXT SYNC socket in the on-telescope CCD camera electronics box. Look for bad connections elsewhere in the timing circuits.[10]

See also § 10.5.

10.5 Star field shows intermittent horizontal lines that look like electrical interference

It is interference and it comes from the refrigeration circuitry. When the vacuum in front of the chip gets to low, the cooling system must work overtime to keep the chip cool, and the extra energy consumption affects the readout circuitry. Ask Dave Doss to have the camera re-pumped, but be mindful that this should be done before or after a run or you'll lose a night.

[9] Since it is recommended that you turn off Quilt and the controller at the end of each night, this should not be much of an issue.

[10] Plagiarism disclosure: Most of the last two paragraphs have been stolen verbatim from Rob Robinson's manual.

10.6 I just got a 'Can't isolate stars' error in Quilt

This is a nasty problem that has still not been isolated. Most likely it is caused by a bad ground somewhere in the hardware setup. If the errors persist, first try rebooting the controller box. Then reseat (disconnect and reconnect) the taxi cable connections both at the controller and on the back of opus (the taxi cable is what connects the controller to opus). If the error is still persistent, put a note in the Night Report, have Observing Support reseat the cables, and come up with a eureka moment to fix this problem in your dreams.

10.7 I just got a Timing Error

This happens from time to time. Make sure to stop the current run (Quilt defaults as continuing to save the data) and restart. If the problem persists to the point of annoyance throughout the night, reseat the coax cables coming into opus and the end that connects to the controller.

10.8 hoth hangs when I shut it down

Perhaps you forgot to shut opus down first. If you must reboot hoth for some reason, unmount /data1 by typing (as root) `unmount /mnt/opus`. For now, use the reset button at the front of the computer.

10.9 The on-line reductions aren't working

Probably an IRAF problem. Close out of IRAF and ds9 and then again go carefully through each and every step in § 6.4.

10.10 A dark patch appears in the center of the star field

You are getting condensation on the chip — a small droplet of water is forming on the CCD window. Any data taken after this point is useless, because condensation affects different parts of the chip differently. Shut down the telescope, and close the dome. The condensation problem is alleviated by the introduction of the dry nitrogen tube, and you shouldn't see condensation below a humidity of 95% (in which case you should be already shut down). If condensation is a problem at a lower humidity, check that the nitrogen is flowing.

10.11 There's a storm comin'

Thunderstorms are common at McDonald, especially in summer, and frequently cause extended power outages. The UPS will supply power to the camera for a limited time, but eventually the battery will drain, effectively turning off the camera without using the switch. The only remedy to this is to turn off the power (using the switch on the electronics box) when you are expecting a storm. You have to guess the weather, and sometimes you will get it wrong. However, don't turn off the camera unnecessarily, as the signal takes a while to stabilize after being turned on, degrading your data quality.

If the power does go out when the camera is on, try if possible to turn the camera off. If the telescope is stowed (very likely) this is impossible, and all you can do is reduce the load on the UPS battery by turning off everything else attached to the UPS: opus and luke should be the only two computers plugged into that UPS, to the right of the work station (hoth should be on its own UPS).

10.12 The dome camera won't start

Did you type `./idload` before trying to run the program? If yes, check your connections.

10.13 The dome camera loads, but only shows a blank image

Check that the lens cap has been removed (sounds dumb, but it's happened).

10.14 The dome is stuck and won't move!

Yeah, it'll do that. Try taking the dome the other direction for a second or two, and see if you can't push it out of that rut.

If the dome slit is stuck, and won't close, there is a circuit breaker that can be flipped directly under the shutters. Have Dave Doss point it out to you if it's your first night, or call him at home if it's 3 a.m. and starting to rain into the dome.

10.15 The focus button won't work

Most likely the focus speed (a dial on the control panel in the dome) is set to zero. The focus does stick sometimes, especially North-South. Try setting the focus speed to maximum and jiggling the focus one way then the other.

10.16 The hand paddle in the control room is blank

This is typically caused on a dry night by the observer's own static electricity. Unplug the hand paddle and reconnect it. It should boot back up and return to normal.

10.17 Quilt has skipped the next run number and won't allow me to enter it

Say the last run was A2435 and Quilt is convinced the next run should be A2439 instead of A2436. First exit Quilt 13. You'll need to edit the 'run name control' file in the root directory. You need 'root' privileges to edit the file, so you'll need to use the 'sudo' command. Open a terminal window and type the following command at the user prompt:

```
sudo echo "A2435" > /.Arun
```

The A2435 above will be the number of you last completed run. After issuing the above command, you will be prompted for the 'ccd' login password. After changing the run number, you can verify it was done properly by typing:

```
cat /.Arun
```

You should see the A2435 printed to the screen. When you restart Quilt, the run number appearing in the Setup window will be the number you wrote to Arun + 1.

10.18 When all else fails

If nothing seems to fixing your problem, try the Microsoft Certified Software Engineer solution. Quit q13 and restart the program. Then reboot `opus` with the `shutdown -h now` command[11]. Then try cycling the power on the camera. When you run out of ideas, call for help.

[11] It may occur that opus has gotten itself so tied in knots that it does not respond to keyboard input. Do not shut down the computer by turning off its power! You may damage the file system, losing data or worse. Instead, log in to opus as ccd from hoth using ssh. Switch to superuser and then execute the shutdown command.