Indian Astronomical Observatory

Mt. Saraswati, Hanle, India

Himalaya Faint Object Spectrograph And Camera (HFOSC)

Users Manual

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Introduction

1.1 Overview of the Instrument

The Himalaya Faint Object Spectrograph and Camera (HFOSC) is an optical imager cum spectrograph built collaboratively at the Copenhagen University Observatory. The instrument is a focal reducer type of instrument i.e. by a using a collimator with the same F-number as the telescope and a camera the effective focal length of the telescope can be reduced. This allows a larger field coverage for a given detector, and also low-resolution grism spectroscopy with the insertion of dispersive elements between the collimator and camera. It is possible to shift between these two modes in seconds.

HFOSC consists mechanically of an optical bench on which the collimator and camera are placed. There are three wheels: an aperture/slit wheel in front of the collimator in the telescope focal plane, a filter wheel and a grism wheel both between the collimator and the camera in the parallel light beam. Between these two latter wheels is a rotational shutter. All wheels have 8 positions. The camera can be moved relative to the end-flange of the instrument. The three wheels have teeth on the outer circumference and are moved by a small tooth wheel which is geared to a stepper motor. The wheels are given a small preload and have a postioning accuracy of 2 μm. The beam from the telescope is bent by 100°, 30 mm after the telescope focal plane to save space behind the telescope mirror.

The converging beam from the telescope passes through an interface unit, the Filter and Spectral lamp Unit (FASU), which is mounted between the telescope instrument mount cube and the main HFOSC instrument. The main instrument is mounted onto this interface unit. The FASU, which houses the narrow band filters and spectral lamps for wavelength calibration, has two filter wheels and three wavelength calibration lamps and one flat-field lamp. Both wheels in the FASU have 5 slots each.

After the telesope beam has passed the FASU, it comes to focus on the aperture wheel in the main instrument. The beam then passes through the collimator and forms a parallel beam. The parallel beam is imaged by the camera on the CCD. As mentioned above, the filter and grism wheels are placed in the parallel beam, in between the collimator and the camera.

The schematic layout of the HFOSC is shown in the Figure 1.1, that of the FASU in Figure 1.2. The basic characteristics are given in the Table 1.1.

The instrument is mounted on the on-axis port of the instrument mount cube of the 2-m HCT.

Table 1.1: Basic characteristics of HFOSC system

Wavelength range	$350 - 900$ nm
Detector CCD Pixel Scale	2048×4096 pixels CCD with pixel size 15 X 15 microns $0.296''$
Collimator focal length	252 mm
Camera focal length	147 mm
Reduction factor	0.58
Spectral resolutions	R 150 to R 4500 using a set of 11 grisms
FOV	10×10 arcmin (unvignetted)
Filters	Bessell UBVRI and 372.7(10), 486.1(10), 500.7(10), 656.3(10), 672.4(10) narrow bands
Performance (not necessarily limiting)	Imaging: R=22.2$\pm$0.18, with exposure time 1200 seconds 2-sigma detection of $\sim$ 23.0 mag/arcsec^2 in 40 minutes (H-alpha filter) Spectroscopy: V=18.5, Resolunion = 300; S/N=22 for exp. time 20min.

1.2 Detector

The detector used with the HFOSC is a SITe ST-002 CCD thinned and backside illuminated chip. It has an imaging area of 2048×4096 pixels of size $15\mu \times 15\mu$ each. The central unvignetted 2048×2048 chip area is used in the imaging mode, whereas part or whole detector is used in the spectroscopic mode. The detector has two output amplifiers, **A** & **B**, which can be operated in both high and low gain modes. Though both amplifiers can be used simultaneously, reading out through a single amplifier is usually prefered for simplicity of reduction. The amplifier **A** is recommended due to its slightly lower RON. The gain and readnoise values obtained during laboratory tests are given in Table 1.2. The sensitivity of the detector in the form of QE varies from 20% near U & I bands to 70% at V& R bands (see Fig. 1.3). The dark counts are found to be 0.3 e^-/h and 2.0 e^-/h in MPP and non MPP modes respectively. The full well capacity in MPP is found to be only 51K ADU and hence counts above 51K suffer from severe nonlinearity in the gain.

The default mode used is amplifier A in the MPP and high gain mode.

The CCD controller takes nearly 20 seconds to clear the detector from residual as well as

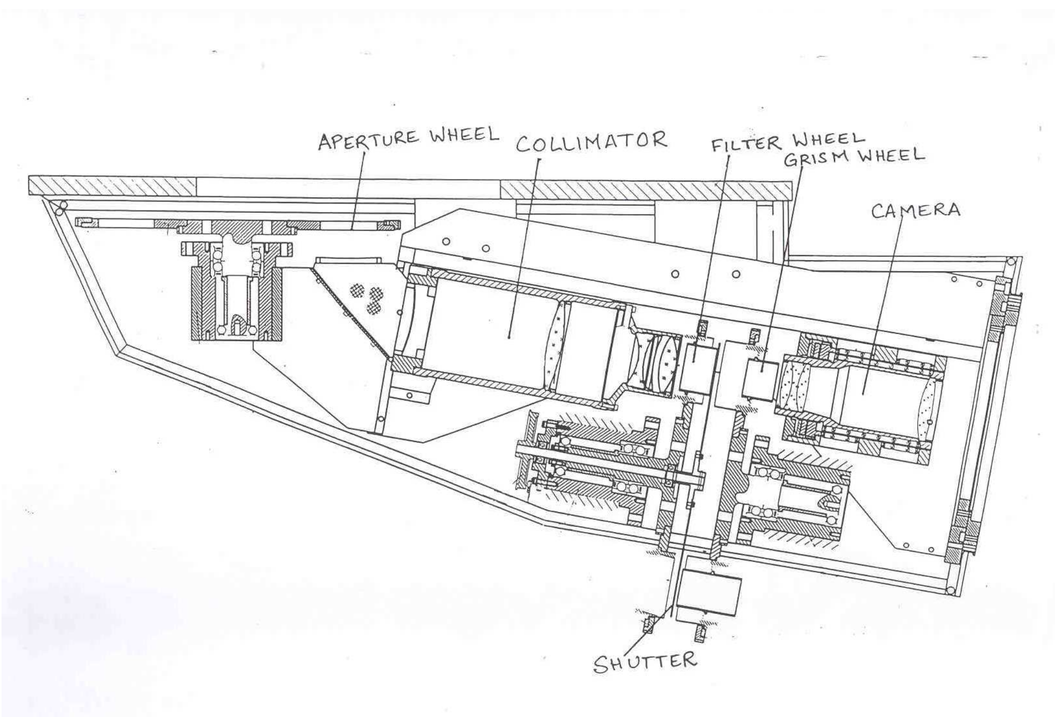

Figure 1.1: Schematic diagram of the HFOSC main instrument.

Table 1.2: Gain and Readnoise of the HFOSC CCD

	Amplifer A		Amplifer B	
	High Gain	Low gain	High Gain	Low gain
RON e^-	4.8	8.0	5.1	8.0
Gain e^-/ADU	1.22	5.6	1.21	5.6

charges accumulated due to dark current. This overhead is due to the special architecture of the SITe CCD being used. The entire $2K \times 4K$ chip is read out in 165 seconds whereas as central $2K \times 2K$ region, used in imaging mode takes only 83 seconds.

1.3 The Software

The HFOSC is operated using two softwares. One for the control of the instrument, and another for controlling the CCD operations.

An IDL based User Interface (UIF) software is used to control the instrument operations such as (a) positioning the two wheels in the FASU, (b) selection of calibration lamps, (c) positioning the aperture, filter and grism wheels, and (d) camera focus

The CCD operations are controlled through the Brorfelde Image Acquisition System (BIAS) software. The interaction between the hardware interfacing to the camera electronics and the user interface is performed by this software. The software enables the observer to make obser-

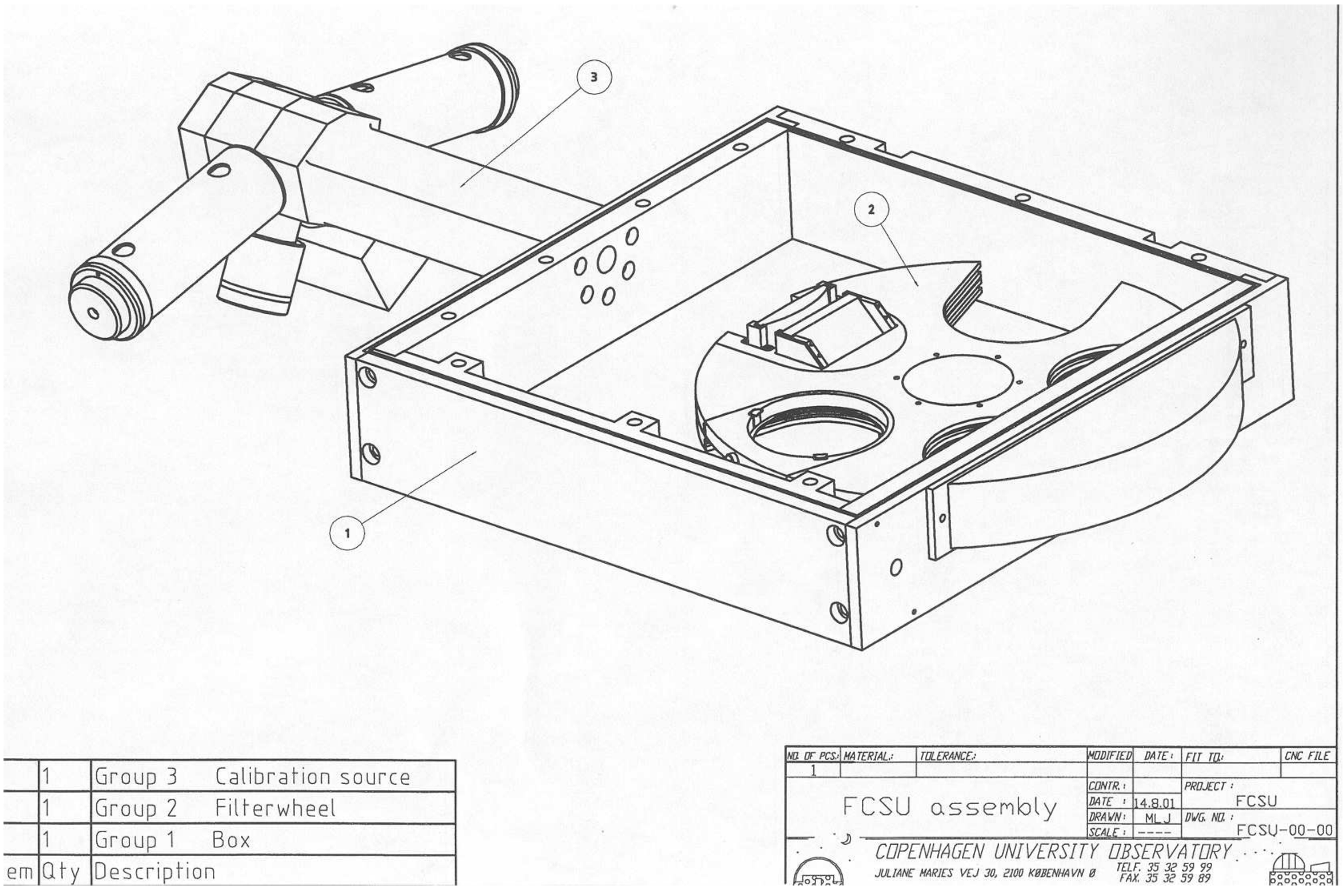

Figure 1.2: Schematic diagram of the FASU.

vations effectively, examine the date online and save the data for later processing.

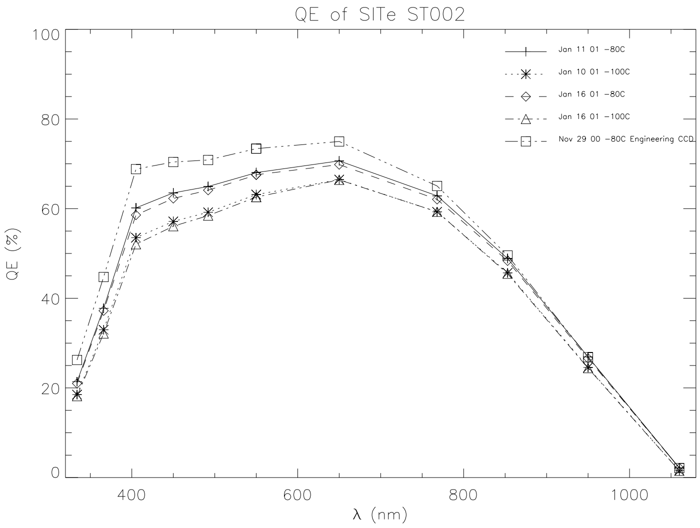

Figure 1.3: Global quantum efficiency versus wavelength for the SITe ST-002 CCD, measured from the sigma-clipped mean of the central area of a flat field exposure. Measurements at -100° C and -80° C are shown to illustrate temperature dependency of QE. For each temperature, measurements are made about 6 days apart, to show the stability of the sensitivity. For comparison, the QE of the engineering grade array is also included

1.4 Slits, Filters and Grisms available with HFOSC

A list of the slits, filters and grisms available with the instrument is given in Table 1.3.

Table 1.3: Available slits, filters and grisms

Slit			Filter	Grism		
slit	width	length		Grism	Wavelength range	Resolution
micron	arcsec	arcmin			Å	
67	0.77	10“	Bes U	Gr 5	5200-10300	870
67	0.77	11‘	Bes B	Gr 7	3800-6840	1330
100	1.15	2.1‘	Bes V	Gr 8	5800-8350	2190
100	1.15	11‘	Bes R	Gr 9 (echelle)	3300-10500	4500
134	1.54	10“	Bes I	Gr 10 (cross disp)	3300-6500	230
134	1.54	11‘	Bes I_c	Gr 11 (cross disp)	3700-7400	390
167	1.92	11‘	Bessell z	Gr 12 (cross disp)	5200-10400	205
335	3.85	11‘	486.1 (10)	Gr 14	3270-6160	1320
1340	15.41	11‘	500.7 (10)	Gr 15	3300-6000	745
			656.3 (10)	Gr 17	7600-10500	2640
			672.4 (10)			

Chapter 2

Observing with HFOSC

2.1 Getting Started

2.1.1 Operating remotely with VNC

The HFOSC system is controlled by a computer named *anders, (WAN) IP address 192.168.100.25* running under Linux Red Hat 6.1 at IAO, Hanle. One can get access into this system through the VNC (Virtual Network Computing) viewer. The command **vncviewer** on the system at CREST will start the VNC. If the command is given with no arguments, it will prompt for a VNC server to connect. Alternatively, specify the VNC server IP number and desktop number (it could be 1,2,3,4 depending on number of vnc servers that have been started):

vncviewer 192.168.100.25:1 -Options

A few useful options are listed below

-shared : Whether to leave other viewers connected. Default false.

-fullscreen Full screen mode. Default false.

-viewonly Block mouse and keyboard events. Default false.

-geometry Specify the size of the desktop to be imported. Default is 1024×768.

-depth Specify the pixel depth in bits. Default is 8.

If the VNC server is successfully connected, the user will be prompted for the password. Once the password is authenticated, a window will appear showing the desktop of the VNC server. To make the VNC faster, it is recommended to start the VNC server and viewer with reduced depth and geometry (recommended depth = 8, geometry = 640×480). Usually the desktop contains an **xterm** window, otherwise clicking the right mouse button will provide a menu to start a new xterm.

2.1.2 IDL User Interface

The UIF is activated in the *xterm* window by issuing the following command

runuif

When the command is activated, a small window pops-up at the bottom of the desktop, broadcasting the progress of the system startup. After a few seconds, a dialog box appears at the top of the desktop window, with the following query
do you want to initialize fosc system
Selection of the *yes* option will initialize all the wheels and the camera focus. During the initialization process two windows are opened, one at the top of the screen, showing the status of all the 5 wheels, the camera focus position, and the status of the calibration lamps. The other window that is opened, to the right of the screen, is the menu-based control of the instrument. The desired setting of the instrument is achieved through selection of the appropriate buttons on the menu.

Fig. 2.1 illustrates the appearance of the desktop with the HFOSC status window and the instrument control widgets.

2.1.3 Starting the BIAS software

The BIAS software is activated by issuing the following commands

cd data1
startb

BIAS will start within a few seconds, opening a status window, an image display window, which is the *Smithsonian Astrophysical Observatory* image utility, and a control window where commands are given for the operation of the CCD. Each window will be described briefly in subsequent sub-sections.

SaoImage:

The BIAS software uses *SaoImage*, a utility for displaying astronomical images which runs under the X11 window environment. The SaoImage includes a main image display window, a button menu panel, a display magnifier, a pan and zoom reference image. Images obtained directly from the CCD or from already saved FITS file in the hard disk can be viewed in SaoImage. A number of push-buttons with various functions are available for controlling the displayed image (see Fig. 2.2). The lower left corner corresponds to (1,1) pixel of the CCD. The x,y coordinates along with the intensity of the cursor position on image is shown in the top part. If the image plane has not been rotated then North is at the bottom and East to the right.

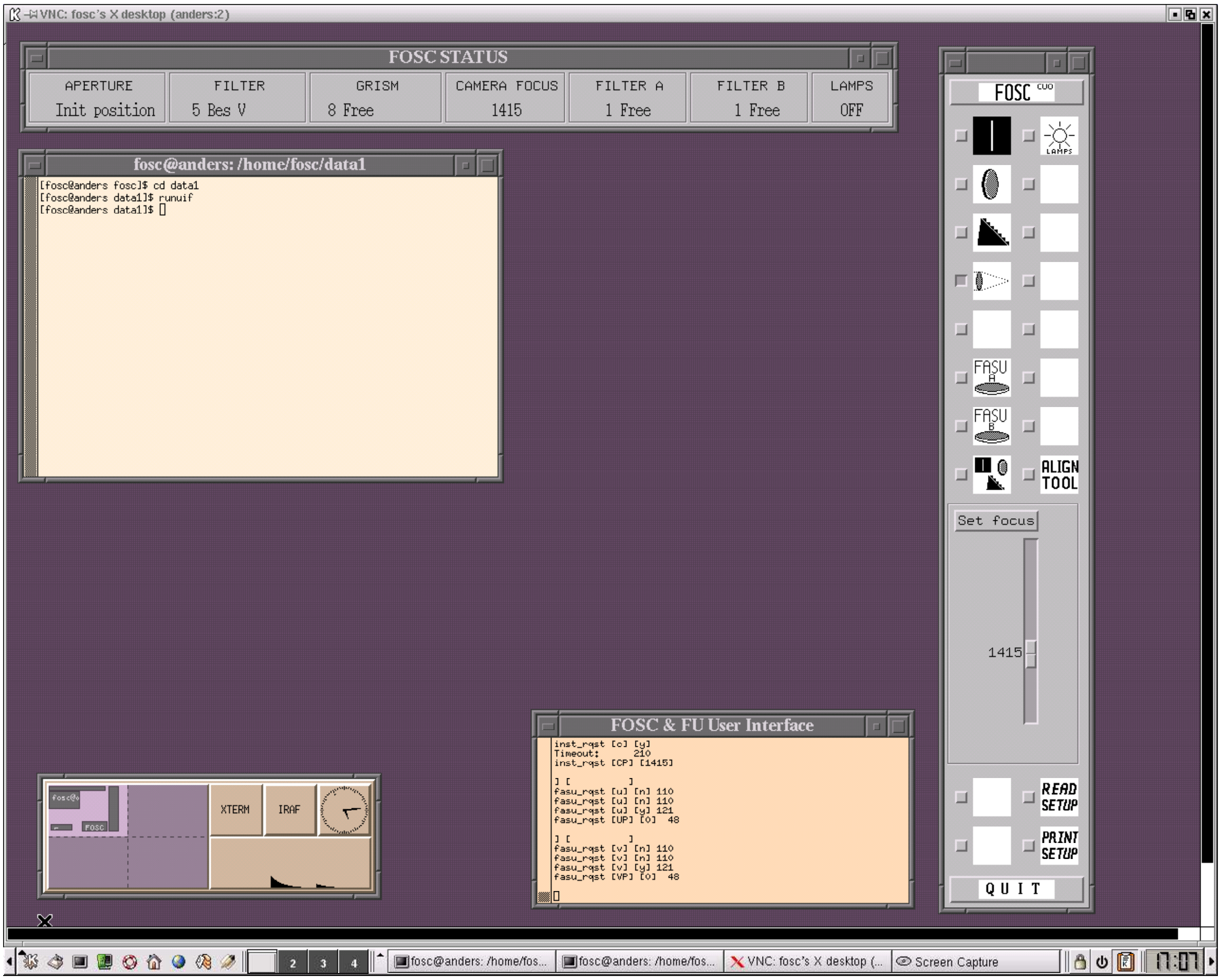

Figure 2.1: A snapshot of the HFOSC user interface window for selection of slits, filters, grisms, camera focus and the calibration lamps.

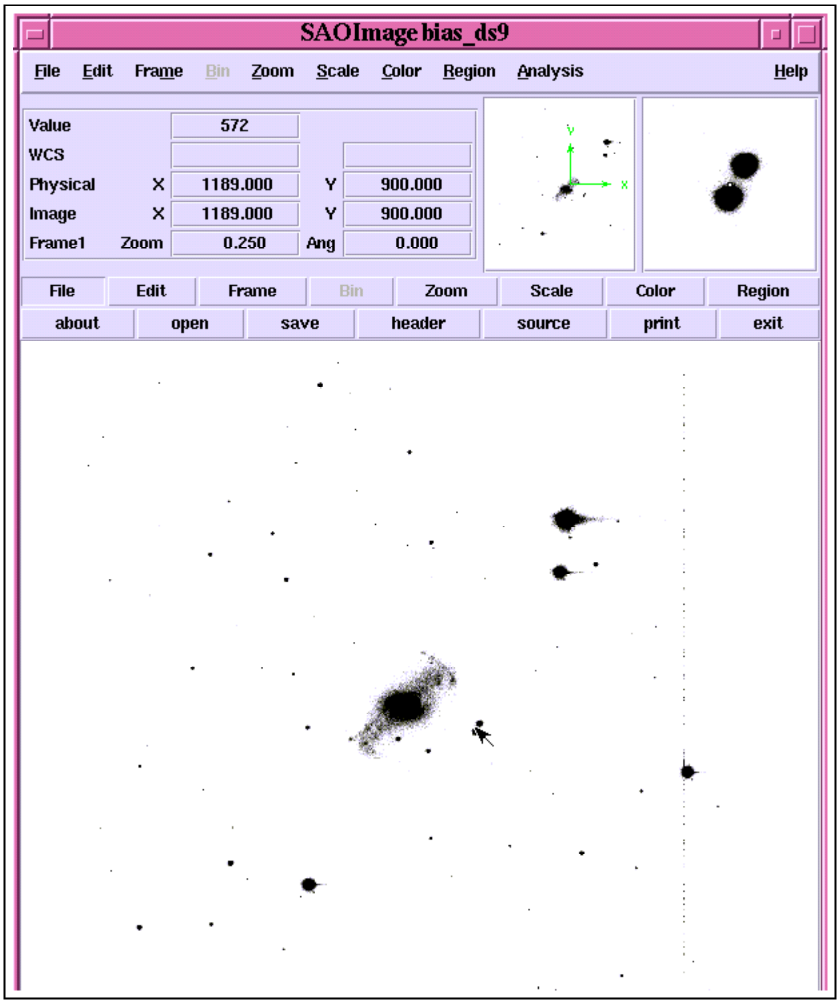

Figure 2.2: The SaoImage display utility.

Bias Status window:

The status window gives information about the setup and the condition of the CCD. The snapshot of the Status window is given in the Figure 2.3. Following is a brief description about the status window.

the first line gives the date and time (in UT)

TOTX and TOTY : Total field size in x and y (physical dimensions)

IMX and IMY : Actual field size chosen.

BEGX and BEGY : Starting pixel x and y values.

BINX and BINY : Binning selected.

The CCD IDLE is the status of the CCD controller, it can be IDLE, CLEARING, INTEGRATING, READOUT or PENDING. IDLE is when the CCD is waiting for a command.

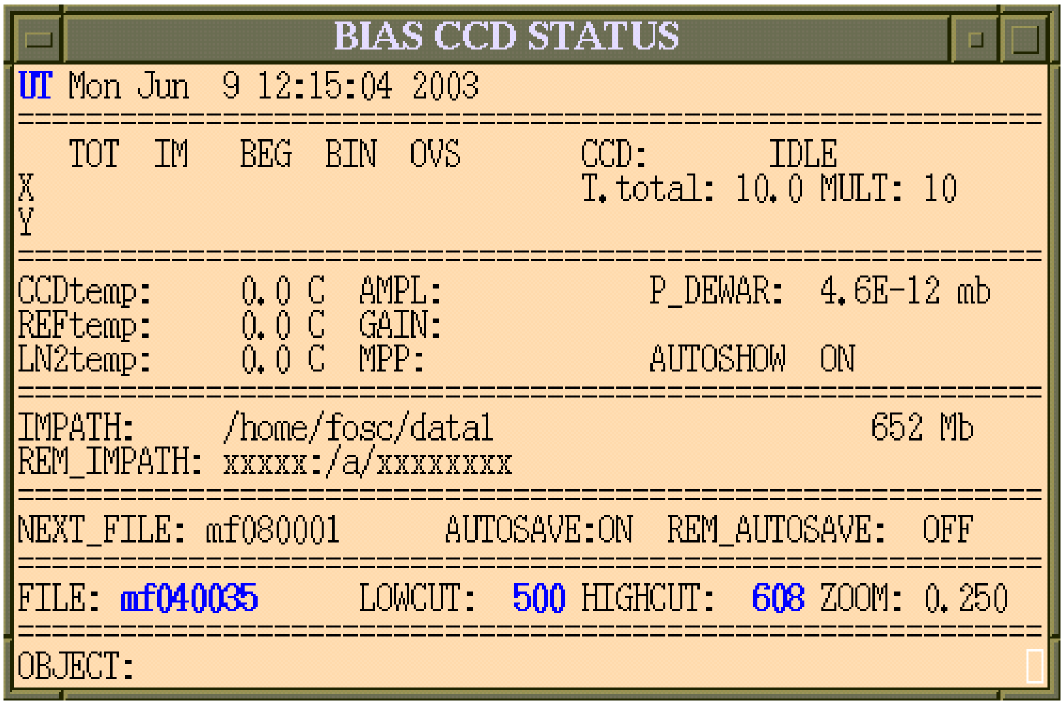

Figure 2.3: Snapshot of the BIAS status window.

CLEARING is during the pre-flush. INTERGRATING is when the CCD exposure is going on. The time left for the exposure is constantly displayed. READOUT indicates that data is being read. The line-number being read out is shown. PENDING is the status during writing the data file on the disk with the appropriate FITS header.

Temperatures and pressure: The next part shows the CCD temperature and its reference temperature. The digits will blink if the CCD temperature is more than 5 degrees from the reference temperature. The Dewar pressure is also shown.

Amplifier and Gain: The 'Ampl' section shows the selected amplifier setup. The selection for SITe chip can be 'A', 'B' or 'AB'. Under this, the gain setting (high or low) is shown, and also the selected MPP mode.

Storing the data: IMPATH is the path of the directory in which the image files and log files are stored. The default value at startup is the current directory, or the directory stated in the '.biasrc' file (see below). Along with this the available disk-space (in megabytes) is shown. The REM_IMPATH is the path on a remote machine, where images are stored.

Image file name: The 'NEXT_FILE' is the name of the next file being stored, 'FILE' is the latest stored-file, or the file displayed in the SaoImage window. If files are being saved automatically after a readout, 'AUTOSAVE' is ON. HIGHCUT, LOWCUT and ZOOM are the values used in displaying the image. The ZOOM value is NOT updated when using the zoom buttons in SaoImage.

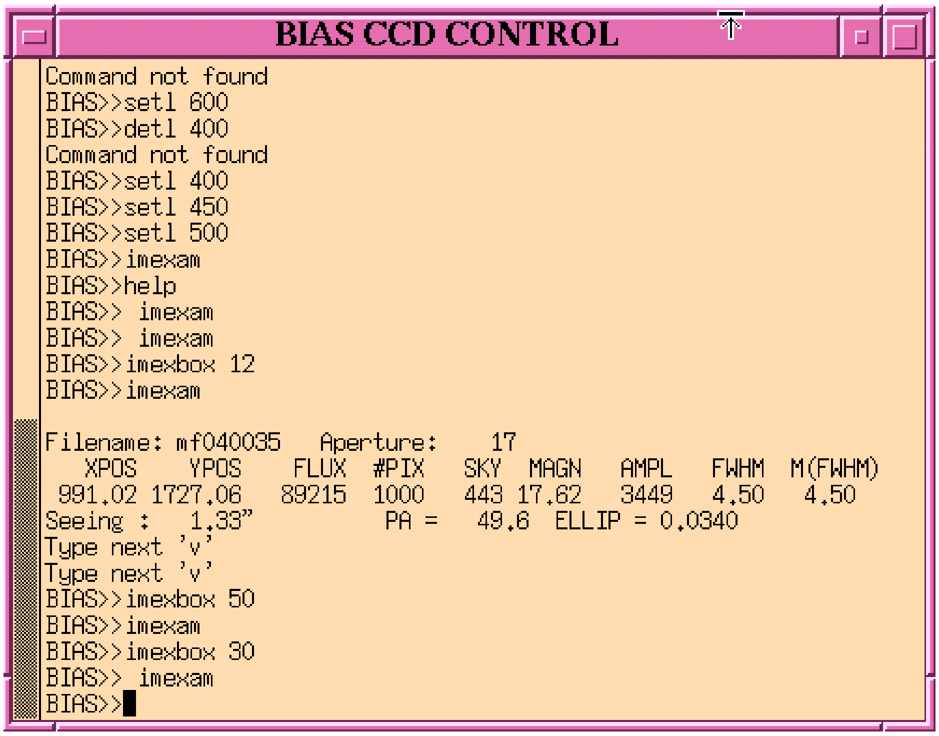

Figure 2.4: BIAS command line window. This is the main CCD controll window where BIAS commands are given to the system.

BIAS CCD Control Window:

This window prompts for the BIAS commands on the command line. At the **BIAS>** prompt, commands are given to the system, with the command parameters. Giving the command alone will prompt for the parameter value, indicating the previous value as default.

It is only necessary to input the necessary number of characters for the system to recognize the command (except for *quit* and *exit*). Backspace or Delete key deletes the last character. The previously used command can be retrieved by the Up/Down arrow keys. The TAB key tries to complete a command or an argument. The mouse can be used to *cut* and *paste* the text in the command window. A few commands do not prompt for data as they use default values if no parameters are used. These are: **exp, mexp, dark, mdark, focus**.

The command "help" generates a help window with short description of all commands.

2.2 Observations

The HFOSC is designed to work in imaging as well as spectroscopic mode. It is very easy to shift between the imaging and spectroscopic modes of operations. In the following subsections, a brief description on how to use HFOSC in imaging as well as spectroscopic mode is given.

2.2.1 Imaging

Selecting an Aperture

Selection of an aperture is through the HFOSC User Interface. HFOSC is used in the image mode by choosing the 'free' aperture. Selection of the aperture is done by clicking on the button in the 'FOSC' window, depicting a slit (first left). A sub-menu pops at the lower half of the same window, indicating the various slits and their corresponding position. Click on the 'free' button. When the aperture is selected, the status window indicates 'Active' during motor movement. Once the motor is positioned, the status window shows the selected aperture.

Selecting a Filter

The appropriate filter selection is made using HFOSC user interface. Narrow band filters are mounted on FASU wheels whereas broad band filters are in the HFOSC filter wheel. For choosing the narrow band filters, click on FASU A or FASU B depending on the wheel in which the filter is mounted. The mount configuration of the FASU wheels is available in Appendix B. The broad band filters are selected by clicking on the button depicting a filter (second left). As in the case of the aperture selection, a submenu pops in each case, and the appropriate filter is chosen by clicking on the relevant button.
Make sure that filter/grism wheels and the FASU wheels other than the one in use are in the 'free' position.

Choosing the Image area

By default, the central unvignetted 2048×2048 image area with unbinned mode is used. This is set by issuing the following commands in the BIAS command line window:

BIAS>resetxy
BIAS>xbegin 1
BIAS>ybegin 1025
BIAS>xsize 2048
BIAS>ysize 2048
BIAS>xbin 1
BIAS>ybin 1

If the observer wishes to use a smaller area of the CCD, the same may be achieved by changing the xbegin, ybegin, xsize and ysize values. Binning is achieved by changing the values of xbin and ybin.

2.2.2 Spectroscopy

Selecting the Slit

The slits are mounted in the HFSOC aperture wheel. Selection is through the HFOSC User Interface, by clicking the button depicting a slit (first left). A sub-menu pops at the lower half of the same window, indicating the various slits and their corresponding position. Click on the button corresponding to the desired slit. When the aperture is selected, the status window indicates 'Active' during motor movement. Once the motor is positioned, the status window shows the selected slit. A list of the slits currently mounted in the instrument is given in Appendix B.

Note: At present there is no autoguider, therefore, long exposures (>600 seconds) with narrow slit (~1") is not recommended. The mean telescope tracking error of 1.38" over 600 seconds would cause the star to move out from slit before the exposure ends.

Selecting a Grism

The grisms are mounted in the grism wheel, and may be selected by clicking on the button depicting a grism (third left) in the user interface. As in the case of the aperture wheel, a submenu pops and the desired grism may be selected by clicking on the appropriate button.

The filter wheel and the FASU-A and FASU-B wheels are to be positioned in the 'free' slot during spectroscopic mode of observations.

Appendix B gives the list of the grisms mounted in the instrument along with the corresponding position in the wheel.

NOTE: Grims 10 and 11, which are used a cross-dispersers with the echelle grism are mounted in the filter wheel. Grism 12, which is also used as a cross-disperser is to be mounted in the filter wheel.

Selecting the calibration source

Fe-Ar and Fe-Ne hollow cathode and Hg-Cd lamps are available for wavelength calibration, while a Halogen lamp is available for flat-fielding. The light from the calibration source is directed into the instrument with the help of re-imaging optics mounted in FASU-A wheel (designated cal-mir). The re-imaging optics ensures the f-ratio of the beam from the calibration source is the same as that of the telescope.

The desired lamp is selected using the 'lamps' button in User Interface (first right).

Appendix E gives the identification of the spectral lines in the sources.

Note that the Calibration Mirror (cal-mir) mounted in the FASU is to be positioned before exposing the calibration source.

Setting image area

Before starting the exposure one has to select the spectral image area. The image region depends on the slit and grism chosen. For the echelle grism, the entire chip is used. For the other grims, the dispersion is along the long-axis of the CCD (y-axis), and almost the entire chip is used in that direction. However, the image size along the direction perpendicular to the dispersion direction (x-axis) may be reduced by using the **xbegin** and **xsize** commands as described earlier.

Centering a star in the slit

As HFOSC does not have a slit viewer it is necessary to use a direct image of the field to determine the offset needed to bring the object to the center of the slit. It is recommended to use a small window of the CCD centered around the slit center (say 400×400 for stellar like objects) to speed up the controller read out. The center of the object can be obtained using imexamin command with *a* keystroke. One can obtain the required telescope off-sets in RA/Dec by supplying the x-,y-position of the star to the program *spec*.

2.2.3 Camera Focus

The camera focus is set using the User Interface, by clicking on the button depicting the lens ray. The selection of the focus position is achieved by scrolling the focus button in the submenu at the bottom panel up or down. After selecting the desired value, click the **set focus** button to set the focus. The focus value in use is shown in the FOSC status window.
The best focus estimate for the HFSOC camera is 1415. A slight dependance on wavelength is noticed, however, the change in focus for the broad band filters is very small, resulting a change in the PSF by only 0.4 pixel or 0.11 arcsec for any seeing value.

2.2.4 Data Acquisition

Data acquisition using the HFOSC CCD is through commands issued in the BIAS command line window. We describe below the commands that are essential during observations.

Bias frames

There is no separate command to take bias frame. The command

dark 0

is used to acquire the bias frame.

Object exposures

Once the telescope is pointed to the desired location and the aperture, filter/grism is set, exposures of the desired field/object may be obtained using

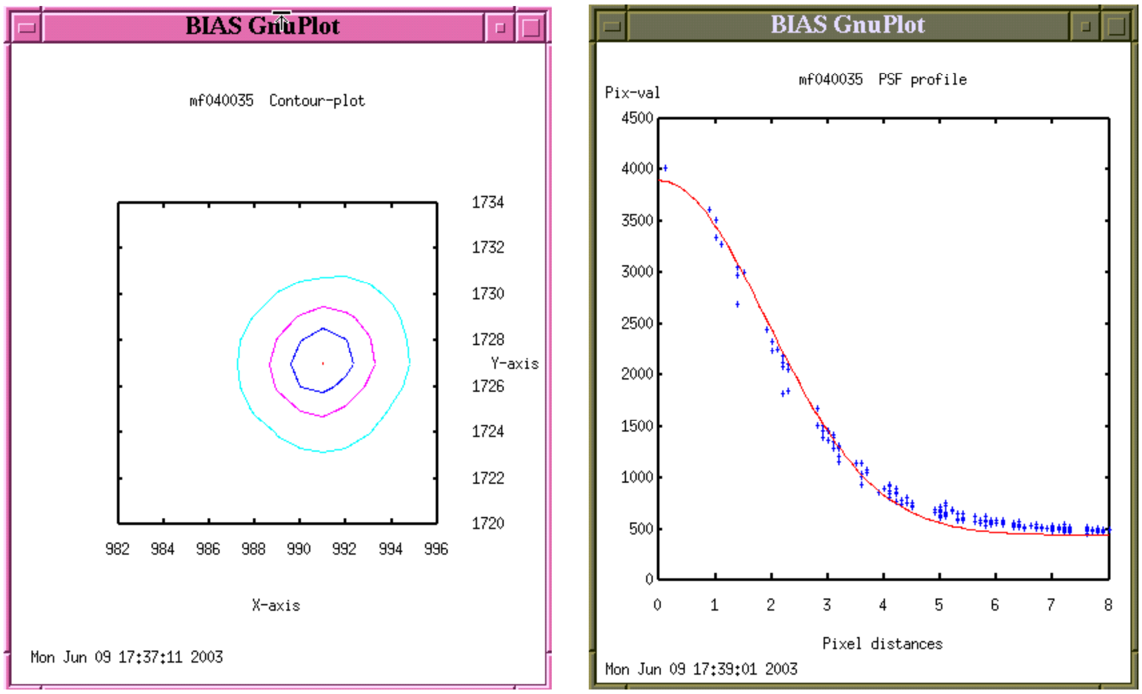

Figure 2.5: The contour and radial profile plots, generated while examining CCD image using BIAS *imexamine* command

exp nnnn

where *nnnn* is the exposure time in seconds.

Image examination

The BIAS imexam command replicates the IRAF imexamine command and can be used to examine the displayed image using various key-stroke commands. For example, the key-strokes *"a, e, s"* can be used to check focus and image quality by inspecting radial, contour and surface plots of stars in the field (see Fig. 2.5).
See Appendix C for all available options.

Object name

The command

object xxxxxxxxxxxxxxxx

is used to include the object name (text; 16 characters) into the FITS header. The parameter value of this command is taken from a default value/previous entry if not specified.

Comments

The command

comment xxxx

can be used to include a comment in the FITS header. Value of this text parameter may not exceed 40 characters. There is no default value for this command, and unless specified, the field will remain blank. However, using the **xcomment** command will preserve a previously entered value.

Saving images

Images that are obtained may be saved automatically by using the

autosave+

command. However, it may not always be desirable to have the automatic saving mode. In such a situation, automatic saving of files may be switched off by using

autosave-

command. When automatic saving of files is not activated, the files may be saved using the command

save

This command saves the most recent exposure image.
All data are stored as 16-bit unsigned integers in FITS format.

Filenames

The filenaming is done automatically. The automatic filenaming mechanism gives a default filename with the following convention

```
mj030025
||||||||
||||-------------------   Automatic incremented number
||||
||---------------------   Day of the month
||
|----------------------   Month, a=jan, b=feb, ...
|
-----------------------   Year, 1991 = a, 1992 = b, ...
```

If some filenames already exist when the program is storing, they are not overwritten, but the next free number is found. (might be confusing if some files are deleted and the program is started again.)
A logfile called *logmj03.001* is created, showing all the input/output on the BIAS screen.

Display saved image

Images which are already saved to the disk can be re-displayed on SaoImage using command

disp imagename

One can also read FITS header with **header** command.

2.2.5 Obtaining Flat Fields

At present, there is no provision to take dome flats. Morning and/or evening twlight sky flats are obtained locally at Hanle by the IAO staff. It is possible for the observer to make flat observations from CREST, but, working through the VNC puts constraint on the speed with which subsequent exposures may be obtained during the restricted twilight periods.

Sky flats are usually obatined by pointing the telescope 45-60 degrees above the anti-solar horizon. Telescope is put into track mode and after each exposure it is shifted by 5 arc-second. Efforts are usually made to acquire at least three sets of observations in each filter such that the count levels are 30,000 to 40,000 counts. Normally, exposure times of less than one second is avoided.

In the spectroscopic mode, flats are taken using the Halogen lamp available within the FASU unit.

2.2.6 Observing with batch file

The command **run filename**, is very useful for running often used observing sequences. The file containing valid BIAS commands is executed. When an exposure command is given, the command interpreter waits for the integration and readout to finish, before issuing the next command. The file must be in the current directory or the path must be specified. A simple example of a batch file for observations of the same object through various filters is given below.

```
autosave-
preclear+
impath /home/fosc/data1
autoshow+
resetxy
xbeg 1
ybeg 1025
xsize 2048
ysize 2048

object SN2K3DU
comment Filter U Exp 500s
```

```
exp 500
save
wait
comment Filter B Exp 300s
exp 300
save
wait
comment Filter V Exp 120s
exp 120
save
wait
comment Filter R Exp 120s
exp 120
save
wait
comment Filter I Exp 100s
exp 100
save
wait
```

The *wait* commands causes a pause in the execution of the program until a key is hit. Filters may be changed during the 'wait' period. The *autoshow+* may be replaced by *autoshow-* if a display of the acquired image is not required.

2.2.7 Exiting the software

To exit from the BIAS system, give the command

quit or **exit**

at the **BIAS**> prompt in the control window.
To exit from the User Interface, click on the **quit** button in the FOSC control window.

2.3 Getting the observed data

All data obtained during the night are stored on the HFOSC computer locally at IAO, Hanle. The data are normally downloaded at CREST by the systems engineer the following morning. It is not recommended to download the data during observations as it would slow down the speed of the link and may affect the telescope/instrument operations. At present the maximum rate of data transmission one can expect to get is around 75-100 kbytes/seconds. This implies that one image of $2K \times 2K$ size will take nearly 2 minutes to download from Hanle to CREST.

Generally in imaging observations spanning the whole night, nearly 800 MB data is accumulated by an observer. This takes around 3.5 hrs of downloading time. Once the data are completely downloaded, they are copied into CD.

2.4 Reporting problems

Any problems may be reported to the Astronomer on duty at night. However, it is likely that some problems may not get solved during the night and would be attended to during day time. Please enter all problems encountered in the log book available with the Astronomer on duty.

Appendix A

Troubleshooting

A.1 Unable to get star/object image

1. Telescope mirror cover is closed.
2. Dome and telescope is not aligned.
3. Wrong port has been selected? Check axis controller on the TCC.
4. Check positions of the aperture, filter, grism, FASU-A and FASU-B wheels.
5. Check sky condition.

Appendix B

Present Instrument Configuration

The slits, filters and grisms mounted in the FASU and the HFOSC main instrument are listed in tables B.1 and B.2

Table B.1: Present set-up of the FASU unit

FASU-A		FASU-B	
Position	Filter	Position	Filter
1	free	1	free
2	486.1	2	672.4
3	656.3	3	free
4	Cal-Mir	4	free
5	500.7	5	free

Table B.2: Mounted slits, filters and grisms

Slot	slit	Center	Slot	Filter/Grism	Slot	Grism
1	134 l	(1054,1968)	1	free	1	focus pyramid
2	1340 l	(1054,1969)	2	Gr 10	2	Gr 8
3	167 l	(1022,1968)	3	Bes I	3	Gr 9
4	134 s	(1012,1971)	4	Bes R	4	Gr 7
5	100 m	(1034,1964)	5	Bes V	5	Gr 5
6	67 l	(1050,1969)	6	Bes B	6	Gr 17
7	67 s	(1080,2025)	7	Bes U	7	Gr 15
8	free	-	8	Gr 11	8	free

Appendix C

BIAS COMMANDS

A brief descriptions of frequently used BIAS commands is given in this appendix.

help This starts an xterminal window, which runs the data viewing utility 'less' in a separate xterm window with a short description of the available commands. With the cursor in this window, use PgUp , PgDwn and arrow keys to move around. '/' can be used to search for text. Use 'q' to quit the window. If 'BIAS' is stopped, the window remains, please stop it using 'q'.The mouse cursor must be in the window for any keys to work.

quit Exit BIAS. alias: 'exit'
All windows are destroyed. If an integration is going on, BIAS can be restarted and continued in integration mode.

expose (T) Start a normal exposure with optional integration time T (in seconds). If no integration time, T, is given, the default T given with the 'tint' command is used.

mexpose (T (M)) Start M integrations of each T seconds. If 'M' is left out the program will use the default 'mult'. If 'T' is not given, the default T, given with the 'tint' command will be used.

dark (T) This is for dark exposures. Works as 'exp' with the shutter closed.

mdark (T (M)) This is for multiple dark exposures. Works as 'mexp' with the shutter closed.

focus (T) A focus sequence is started, each exposure of T seconds. At the completion of each exposure, you are prompted to start a new (hit the 'space bar'), or finish the sequence (hit 'q') and readout the ccd. At this time, there is no option to move the telescope and focus from this program.

abort Stop an ongoing integration or readout. The data are NOT readout, and can not be recovered.

readout Readout the CCD now and store the image. The correct resulting integration time is stored in the FITS header.

addtime (nn) Add 'nn' seconds to the integration time. Negative numbers are allowed. If the resulting integration time is negative and larger than the remaining integration time the CCD is readout.

hold During an integration, the shutter is closed and the CCD is not readout.

resume Resume a previously 'hold'. The final integration time may vary by a few hundred milliseconds.

clear Clear the CCD.

ccdreadout-

ccdreadout+ These 2 commands set/reset a flag controlling whether the controller should readout the ccd after an integration. Please note that the integration time in the FITS header will not be correct, when this command is used with the command 'preclear-'.

preclear-

preclear+ Controls whether the ccd controller clears the ccd before an integration. The flag is reset (to preclear+) after an actual readout.

save Save the image stored in the computer memory and shown in saoImage. Useful if 'autosave' has been off.

save8 Save the current image as 8 bit FITS image. Uses a linear transformation between lowcut and highcut.

header [name] View the FITS header in an image file. Starts an xterm window with 'less' on the filename. Works like 'help'.

tint (T) Set the default integration time in seconds.

mult (M) Set the default number of multiple integrations.

xbegin (X) Set the xvalue of the first pixel to be read-out from the CCD. The values start with 1. If xbeg + xsize is larger than the CCD's total x-width, xsize is reduced. Default = 1.

ybegin (Y) As 'xbeg' in the y direction (lines). Default = 1.

xsize (XZ) Set the x size of the image to read-out. Default = 2052.

ysize (YZ) Set the y size of the image to read-out. Default = 2052.

xbin (n) Set the binning in X direction. xsize might be adjusted when an integration is started if amplifier AB (2 amplifiers) is used and the resulting number of pixels on a line is uneven.

ybin (n) Set the number of lines to bin.

bin (n) Set the X and Y binning to the same value. Alias 'xybin'

resetxy Reset the size, beg and binning values to the default.

xoverscan nn This value defines an overscan in x. Actually the command redefines the controller to believe the ccd is actually nn pixels wider. For that reason a 'resetxy' is performed automatically. When using partial readout, an over-scan will only be available if the actual readout exceeds the physical ccd. This means that to get overscan with:
ampl A: xbeg+xsize-1 > physical ccd size
ampl B: xbeg < xoverscan
ampl AB: Overscan will be there due to the readout scheme. The image line is first centered in the serial shift register, and then readout. 2 zones of each xoverscan/2 will appear at the right of the image, one for ampl A, the other for ampl B.

yoverscan nn Overscan in the y direction. Extra dummy lines are read out.

gainlow Set the CCD preamplifier gain to low gain.

gainhigh Set the CCD preamplifier gain to high gain. High gain is 2.2 times low gain.

mpp+ Set MPP mode ON. Alias 'mpp'.

mpp- Set MPP mode OFF.

ampl (XX) Select the ccd output amplifier used. This ccd has 2 amplifiers (A and B) at the end of one serial shift register. Default is ampl A, valid values for XX is: A, B or AB.

autosave+ Store the CCD images in the specified 'impath' after each exposure. When files are stored, there is a check for the remaining diskspace. A warning is given at 20 Mbyte remaining, with ¡10 Mbyte left the file is not saved. Alias 'autosave'.

autosave : Do not store images readout. This is often used for a quick look. A warning is given at the start of every integration if autosave is off. Images can manually be stored with 'save'.

remsave+ Turn on saving on remote disk. The remote workstation and path must be defined in '.biasrc'. Alias 'remsave'.

remsave- Turn off saving on remote machine.

impath (path) Set the directory (or path) where images and logfiles are stored. Default is the startup directory. The specified path is checked for write permissions, and access is denied if the permissions are inadequate.

remsystem some_server Use the remote UNIX machine 'some_server' for storing remote.

rempath (path) Set the remote path for storing of images.

filename (name) Specify the next filename to use. The first character must be a letter, the length ¡= 8 and the last 4 characters must be digits. The last 4 digits are incremented every time an imagefile is stored with a check for the existence of the new filename. When specifying the 4 last digits, any number can be specified as the starting value.

autoshow+ Show images in SaoImage. Alias 'autoshow'.

autoshow- Do not show images in SaoImage.

ls Unix list 'ls' in the impath directory.

ll Unix long list 'ls -l' in the impath directory.

imexamine Start a pseudo Iraf imexamine in the SaoImage window. The cursor moves to the SaoImage display window. Hitting the below listed keys starts the described action at the cursor position. The plot utility 'gnuplot' is used for graphical output. At this time the following commands are implemented. Please note the commands that use the aperture size while others use the imexbox.

- **a :** aperture photometry. Calculates center, sky and flux. Also FWHM, ellipticity and position angle.
- **z :** Print the values of the pixels in a 10x10 box around the cursor.
- **m :** Calculate statistics in the aperture.
- **c :** Plot the cursor position column across the entire image.
- **l :** Plot the cursor position line across the entire image.
- **s :** Make a surface plot from inside a box specified by the command 'imexbox'.
- **e :** Make a contour plot from a box specified by the command 'imexbox'.
- **v :** Vector plot. The 1. position is where the mouse pointer was when 'v' was typed, 2. position when the next 'v' is typed.
- **u :** Vector plot symmetrically around 1. position. 2. position when a second 'u' is typed.
- **= :** Print on the postscript printer the last plot. The plot screen disap-pears for a few seconds.

- **h :** Print a histogram of the entire image.
- **X :** Bin the image in the x direction, and display.
- **Y :** Bin the image in the y direction, and display.
- **q :** quit imex, and return to BIAS.

Please note that when an integration has just finished, imexamine is automatically aborted and program control returned to BIAS.

imexbox (IB) Specify the box size used for the imex commands s and e.

aperture nn The aperture size in pixels. (adjusted to an uneven number).

magzero nn.nn Set the magnitude zero value for aperture photometry in imexamine

display (name) Display a FITS image in SaoImage from the harddisk. Alias 'ld'.

sethigh H Set highcut and show the image in SaoImage. Alias 'z2'.

setlow L Set lowcut and show the image in SaoImage. Alias 'z1'.

z+ Zoom in and out. This zoom works independantly from the

z- SaoImage zoom, this means that the zoom shown in the status display might be wrong. z+ and z- has the advantage the zooms of other factors than 2 can be used.

object (Obj) Specify a text to be put into the FITS header with the keyword OBJECT. The object text is left unchanged until next 'object' command. Maximum no. of characters is 16.

comment (text) Comments to put into the FITS header. Maximum 40 characters. The text is cleared after it is used in the header.

xcomment (text) An additional comment field. This comment is NOT cleared after being written to the FITS header.

logon Start a log of BIAS command screen input / output. By default a log file is created.

logoff Stop the logging.

rbias Re-read the '.biasrc' file. If the file has been changed, this command re-reads the user setup.

run (filename) Run a batch file. The file containing valid bias commands is executed. When an exposure command is given, the command i interpreter waits for the integration and readout to finish, before issuing the next command. The file must be in the current directory or a the path must be specified. The command is especially useful for often used sequences, perhaps with special geometry.

sleep tt Suspend the processing of a batch file for 'tt' seconds.

wait Wait until a key is hit. Useful in 'run' scripts.

status An 'R' for ready, or a 'B' for busy is returned, indicating the status of the camera. (only ready when IDLE). This is a preparation for remote control of the software. The ccd temperatures and and optional pressure is also printed, along with the line number being readout and the exposure time left.

xrun boxsize command Control is sent to the SaoImage window, when hitting the 'space' bar, the area of the image defined by boxsize is stored in a file called '?????', and 'command' is executed as a system call.

saoimage Earlier versions of SaoImage were somewhat unstable. Use this command to restart saoimage.

Appendix D

FITS Header

The FITS header at the start of the files contains information about the exposure. You can view a file header with the 'less filename' utility in a seperate xterm window, or with the 'head filename' command from inside BIAS.An example is shown here.

OBSERVAT= ' ' /
TELESCOP= ' ' /
INSTRUME= 'HFOSC ' /
DETNAME = 'Site 2kx4k ' /
DATE = '2002-12-16T06:59:12'/
DATE-OBS= '2002-12-11' /
FILENAME= 'll110010' /
OBJECT = 'GRB021211/R/600' /
EXPTIME = 600.000 /
TM_START= 76714 / 21/18/34 UT start time
TM_END = 77447 / 21/30/47 UT end time
CRVAL1 = 1 /
CRPIX1 = 5.0956130027771 /
CDELT1 = 1 /
CRVAL2 = 1025 /
CRPIX2 = 1.91363000869751 /
CDELT2 = 1 /
COMMENT =
COMMENT =
GAINM = 'HIGH ' / High or Low
AMPLM = 'A B021211/R/600 ' / A / B or AB
CCDTEMP = -100.1 /
LN2TEMP = -186.2 /
COMMENT =

MPP = 1 /

CHIPID = 'SITe002 2K x 4K ' /

XOVERSC = 0 /

YOVERSC = 0 /

P_DEWAR = 3.5E-07 /

UT = 76714 / 21/18/34 UT start time

SHSTAT = 'OPEN ' /

APERTUR = '8 Free ' / FOSC Aperture ID, step position = 280000

FILTER = '4 Bes R ' / FOSC Filter Description

FILTID = 75 / Filter number. 0 = Empty or N/A

FILTPOS = 120000 / FOSC Filter wheel step position

GRISM = '8 Free ' / FOSC Grism ID, step position = 280000

CAMERA = '1415 ' / FOSC Camera focus

AFILTER = ' 1 Free ' / FU #A Filter description

AFILTID = 0 / NOT Filter number. 0 = Empty or N/A

AFILTPOS= 0 / FU #A filter position

BFILTER = ' 1 Free ' / FU #B Filter description

BFILTID = 0 / Filter number. 0 = Empty or N/A

BFILTPOS= 0 / FU #B filter position

LAMP = 'OFF ' / Calibration lamp value = 0

WCSDIM = 2

CTYPE1 = 'LINEAR '

CTYPE2 = 'LINEAR '

CD1_1 = 1.

CD2_2 = 1.

LTV1 = 4.0956130027771

LTV2 = 0.91363000869751

LTM1_1 = 1.

LTM2_2 = 1.

WAT0_001= 'system=image'

Appendix E

Comparison Spectrum

The identification chart of FeAr and FeNe comparison lamps obtained using Gr 7 and Gr 8 are presented here.