F Appendix F

Data reduction method

A step by list of instructions on how to reduce the data obtained from the EFOSC2 spectrograph on the New Technology Telescope at La Silla, Chile.

NTT data 2011 & 2012

First rename the data into something more user friendly, e.g.

- bias_001_160811.fits
- flat_001_160811.fits
- HeAr_01_160811.fits
- HD002913_01_170811.fits

Keep all numbering in order from 001 to 190 (or whatever number you get to) but alter date so that it is clear which files belong to which days.

Rename the files and put these into the renamed_data directory. Copy the renamed files to the relevant bias, flat, HeAr and science directories in the directory for the date of the observations. e.g, NTT_2012, 087.C0405A, 087.C-0405B to run the midas code to reduce the data.

Check statistics on the frames using IRAF (more detail than with midas) do this in the renamed_data directory

- source /packages/pyraf/setup.csh
- mkiraf
- xterm
- kwrite login.cl & (make imdir path same as home path; save and exit)
- pyraf
  - *fields="image,npix,mean,midpt,mode,stddev,min,max (Gives stats for fields itemised in the area defined by the pixel range [xs:xe, ys:ye] in all bias frames)*
- imstat bias*.fits[50:980,50:2000] fields="image,npix,midpt > biasL.txt (gives stats as stated above in all bias frames and out puts this to a file which can be viewed with kwrite)
- imstat bias*.fits[1500:2010,50:2000] fields="image,npix,midpt > biasR.txt (Puts same information as above in to file biasR)
- imstat bias*.fits[2000:2050,0010:2010] fields="image,npix,midpt > biasFR.txt
- imstat flat*.fits[1500:2010,50:2000] fields="image,npix,midpt > flat.txt
- imstat HD*.fits[1500:2010,50:2000] fields="image,npix,midpt > science.txt
- imstat flat*.fits[2000:2050,0010:2010] fields="image,npix,midpt > FRflat.txt
- imstat HD*.fits[2000:2050,0010:2010] fields="image,npix,midpt > FRscience.txt

Use above stats to put into a spreadsheet and analyse/produce graphs. See Bias_ratios.xls and statsgraph1-1.xls for March 2011 analyses also see green file for NTT info with print out of how bias frames were scaled (addition rather than multiplication).

This gives details of the noise levels on both halves of the bias frames (Left and Right) and

the un-illuminated part of the flat and science frames with the area chosen on the right hand side being common to all types of frame for fair comparison. It was noted that the levels on the bias frames which were taken at the start of the evening where much higher than on the science frames taken later on. This implied that the bias levels were not stable throughout the night as the un-illiminated part of the science frames should reflect the true bias levels. It was noted that some bias frames had higher levels than others and it is likely that some light seepage did occur and become recorded on the ccd. For this reason the very far right had side of the frames were sampled and analysed using the pixel range [2000:2050,0010:2010]. Ultimately need to scale bias frame to the lowest level of the median value on the science frames.

On spreadsheet enter the image name [with range of pixels selected], npix, midpt, for bias, flats and science frames. May only need to record the median values in future as these were the values we worked with, although it was good to look at and consider all other values. The column for the science midpt can be copied and pasted in a separate column at the end which can be rearranged to sort in order of value to find the lowest value of all the frames to be used to scale a bias frame to. Have separate days on separate sheets. On tab bias_diff enter the midpt values in a column total and take the mean value. If any frames are very much different in level to the majority of the others omit these and recalculate a mean value. Enter the mean value in another column and then work out the difference between each frame and the mean value so there is an addition factor which will make all bias frames up to a steady level for each side.

Once an addition factor has been calculated for each bias frame load midas to scale individual frames, make a master bias and scale to the right level for use with science frames and flat frames:

- copy bias frames from the renamed directory to a separate directory for each day
- inmidas
- set/context long (for long slit spectroscopy)
- crea/icat bias190812 bias*.fits

scaling a bias frame

@@ bias_ext bias190812

- this runs the midas code ' bias_ext.prg' which does all of the following steps. This code must be in the same directory as the files it is to work with

  - cp bias_001_210311.fits biass_001_210311.fits (do this for all frames in main directory NOT midas! Biass stands for scaled bias)
  - extract/image extractL0001= bias_001_210311.fits [@1,@1:@1030,@2060] (extracts the left-hand side of the bias frame)
  - repeat for all bias frames
  - extract/image extractR0001 = bias_001_210311.fits [@1031,@1:@2060,@2060](extracts the right-hand side of the bias frame)
  - repeat for all bias frames

From spreadsheet (bais_dff tab) print off the page for the add factor to scale each frame

then **manually** scale the frames halves in the following way:

- compute/image 001L = extractL0001+10.8 (scales the left-hand side to 222.6 median value for 190812)
- repeat for all frames and using the addition factor as calculated above for each frame
- compute/image 001R = extractR0001-10.87 (scales right-hand side to 137.83 median value for 190812)
- repeat for all frames and using the addition factor as calculated above for each frame
- crea/icat ins_L *L.bdf
- crea/icat ins_R *R.bdf

@@ bias_insL ins_L biass_ins

- this runs the midas code ' bias_insL.prg' which inserts the scaled LHS into the biass_ins frames
- insert/image 001L biass_ins0001 @1,@1

@@ bias_insR ins_R biass_ins

- this runs the midas code ' bias_insR.prg' which inserts the scaled RHS into the biass_ins frames
- insert/image 001R biass_ ins0001 @1031,@1

Manually convert biass*.bdf into fits files to check stats in Iraf.

- outdisk/fits biass_ins0* biass_ins0* ? .fits

IN IRAF

- source /packages/pyraf/setup.csh
- mkiraf
- xterm
- kwrite login.cl & (make imdir path same as home path; save and exit)
- pyraf

- imstat biass*.fits[50:980,50:2000] fields="image,npix,midpt" > biass_Lhs.txt
- imstat biass*.fits[1500:2010,50:2000] fields="image,npix,midpt" > biass_Rhs.txt

use above to view in kwrite and check all is OK and reasonable values

make master bias

- average/images biass190812 = final.cat ? ? median
- to check effectiveness of the master bias in comparison to an individual bias frame
  - load/image biass190812 0 scale=-5 cuts=80,300
  - load/image biass_ins0015 1 scale=-5 cuts=80,300
  - blink 0,1 0.5

scaling the new master bias frame to the level of the science frames

- compute/image biasss190812 = biass190812-36.03
  - (scales the right-hand side down to level of lowest value on all science frames [101.8 on 19th] from the median value calculated for that day on the bias frames on the spreadsheet [137.83 on 21st]. Biasss stands for scaled bias further scaled to level of science frame i.e. [137.83 – 101.8 = 36.03])
- to check effectiveness of the above scaling
  - load/ima biass190812 0 scale=-5 cuts=80,300
  - load/ima biasss190812 1 scale=-5 cuts=80,300
  - blink 0,1 0.5
- extract/image biassse190812.bdf = biasss190812.bdf [@17,@6:@1393,@2032]
- rot/clock biassse190812.bdf biassser190812.bdf

To match step sizes:

- write/desc biassser190812.bdf start 1,1
- write/desc biassser190812.bdf step 1,1
  - Note: read/descr biassser190812.bdf start etc., shows the values of the step sizes to us for checking problems
- Put biassser190812 in same directory as the science frames it is to be subtracted from

scaling the new master bias frame to the level of the lowest bias frame for use with flats

- compute/image biassfs190812 = biass190812-26.33
  - (scales the right-hand side to level of lowest/last value (depends on trend throughout night. Mostly take lowest level unless the start of night values are erratic and settle towards the end of the night to a reasonably steady level which may be higher than the lowest level) on all **bias frames** for that night [111.5 on 19th as given by the far RH side values] from the median value calculated for that day on the bias frames on the spreadsheet [137.83 on 19th highlight in red the figure used]. Biassfs stands for scaled bias further scaled to level for use with flat field to distinguish it for the bias frame to use with the science frames i.e [137.83 – 111.5 = 26.33])
- to check effectiveness of the above scaling
  - load/ima biass190812 0 scale=-5 cuts=80,300
  - load/ima biassfs190812 1 scale=-5 cuts=80,300
  - blink 0,1 0.5

To match step sizes:

- write/desc biassfs190812.bdf start 1,1
- write/desc biassfs190812.bdf step 1,1

- Put biassfs190812 in same directory as the flat frames it is to be subtracted from

creating a master normalised flat field frame

- move to flat frame directory in calibration directory to use midas for creating a normalised flat field frame
- make sure the midas programme flat.prg (flat3.prg) is in the right directory for midas to use
- crea/icat flat190812 flat*.fits

@@ flat_prep flat190812

- this runs the midas code 'flat_prep2.prg' which subtracts the bias from each frame extracts the image and rotates it. As the steps as described manually below:
  - comp/ima flatb0001 = flat_001_210311.fits-biassfs21.bdf
  - extract/image flatbe0001 = flatb0001.bdf [@17,@6:@1393,@2032]
  - rot/clock flatbe0001 flatber0001
  - statistics/image flatber0001.bdf + option=G (for all frames to be used)
  - make note of median and mode values in spreadsheet (statsgraph1-1.xls dividing_flats sheet)
  - comp/ima flatberd0001 = flatber0001/2554.75 (divide each flat by its median value repeat for all on separate days)
  - create/icat flat flatberd*.bdf

@@ flat3 flatbd190812 flat190812n 49

- this creates a normalised flat called flat21n.bdf using the catalogue flatbd190812 and smoothing parameter of 49 and stores information on Median-averaged median-averaged rows in medav.bdf and median-averaged smoothed version in smoot.bdf.
- Can use smoot.bdf. After a spectrum has been extracted to divide through by so the spectrum is corrected for wavelength-dependant throughput
- median-averaged rows can be used to check what smoothing is appropriate to use, especially for smoothing out fringing – do this on individual flat basis (catalogue with just one flat in it.
  - to check
  - load/ima flat190812n 0 scale=-5 cut=-0.0005,1.5
  - load/ima flatberd0015.bdf 1 scale=-5 cut=-0.0005,1.5
  - blink 0,1 0.5
- this shows that the variations in intensity from left to right have been evened out. Viewing the medav and smoot frames show that all the detail of lines has been removed and it is an even image with some gradual gradients in intensity

To match step sizes:

- write/desc flat190812n.bdf start 1,1
- write/desc flat190812n.bdf step 1,1
- move flat190812n to directory where science frames are

Wavelength calibration:

Move to calibration file HeAr make sure hear.tbl is in this directory

- extract/ima HeAre_01_210311 = HeAr_01_210311.fits [@17,@6:@1393,@2032]
- rot/clock HeAre_01_210311 HeArer_01_210311
- write/descr HeArer_01_210311 step 1,1
- write/descr HeArer_01_210311 start 1,1
- crea/dis 0 900,512 (crates a display on channel 0 which is longer than it is wide)
- load/ima HeArer_01_210311.bdf 0 scale=-3 cuts=80,800 (To print off dispay to match up)
- load/ima HeArer_01_210311.bdf 0 scale=-1 center=300,300 cuts=80,800 (to zoom in and get cursor to identify pixel numbers the line falls on to estimate different wavengths)
- create/gui long (set line catalogue to hear.tbl wavelength range 5700 - 6800)
- search
- search on
  - click on HeArer_01_210311.bdf
- plot
- identify
- begin
  - use cursor to identify line and select a wavelength to match it to
- *(can load saved parameters and calibrate all if coming back after a break)*
- calibrate (on main window)
- calibrate all
- check results with Dispersion and residuals make a note of the starting and final wavelength and the step size. Repeat for all HeAr frames. If all are very similar especially in step size there is no need to combine them. Choose the frame which has the closest fit to the line and least dispersion.
- Save parameters, labelling the table as day and frame i.e 16_01
- Move chosen table to science directory with all other necessary files (210812_07COE.tbl, 210812_07.tbl)

To prepare science frames:

1. move to science directory which contains all science frames for one day, the master bias for use with science frames (biassser21.bdf) and master normalised flat frame (flat21n.bdf). Make sure all necessary calibration frames and tables are in the same directory (hear.tbl, 190812_02COE.tbl, 190812_02.tbl) as well as the midas programme for the day (science_prep190812.prg)

- crea/icat sci210311 HD*.fits

- to create a catalogue to loop over.
  - create/gui long
  - load saved parameters (190812_02.tbl)
  - calibrate all
  - @@ science_prep190812 sci190812
- this runs a midas code 'science _prep.prg' which does all of the following steps plus removed the intermediate frames from the directory.
- extract/image HD138764e_01_210311 = HD138764_01_210311.fits [@17,@6:@1393,@2032] (for all frames)
- rot/clock HD138764e_01_210311 HD138764er_01_210311 (for all frames)
- write/descr HD138764er_01_210311.bdf start 1,1
- write/descr HD138764er_01_210311.bdf step 1,1
  - for all frames to match step/start values
- comp/ima HD138764erb_01_210311 = HD138764er_01_210311-biassser21
  - for all frames subtracting midas bias frame from science frame
- comp/ima HD138764_01 = HD138764erb_01_210311.bdf/flat21n_3.bdf
  - for all frames dividing midas subtracted science frame with midas flat (originally this had extension erbfn after the target name and the full date; however, it needs shortening to use with gui and to be easier to manipulate as a final frame)
- rebin/long HD138764_01.bdf HD138764_01_reb
  - files in directory are of form reb0001.bdf and a catalogue of these names with the target identity they relate to is found in the catalogue 'final' use this to rename the files as something useful at the extract spectrum stage.

Extracting a spectrum

- **move to science directory which contains all science frames for one day, the master bias for use with science frames (biassser21.bdf), master normalised flat frame (flat21n.bdf) and all files from the wavelength calibration.**
  - load/ima reb0001 scale=3 center=C,@300 cuts=0,50 (to check sky and object values, was @876 for first frames in march 11 data. Also may need to play with cuts, Aug 12 data needed counts of 0,300, need scale=-5 center=C,@300 cuts=65000,66000 to check for a spectrum being saturated)
  - get/cur to identify sky levels and spectra limits

- alter the centre value to C,300 for targets imaged after 03:30 on the 21st March 2011
  - extract/long reb0001 HD052918_01 20 855,897 3,3 0,0.1,100 (for later spectra range will be about 265,321)
  - graph/spec
  - plot/row HD052918_01 @1
  - set/gra xaxis=5750,5910 yaxis=400000,460000 (if you want to zoom)
  - comp/ima HD052918 = HD052918_01+ HD052918_02+HD052918_03 (combine into a single spectrum)
  - plot/row HD052918 @1
  - set/gra xaxis=5650,6810 yaxis=10000,650000 (to find spectrum)
  - set/gra xaxis=5750,5910 yaxis=230000,10000000 (to find sum of spectra)