A Quick Guide to Reducing WIYN Hydra Data

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The following gives a sketch of the reduction steps used to reduce some recent Hydra obtained at WIYN. The data set *corresponding to a single fiber configuration* consisted of the following images.

- dome flat exposures: n190027, n190028, n190029
- comparison exposure: n190026
- object frames: n190023, n190024, n190025
- bias frames: n190030-39
- an ".iraf" file generated by the positioner software called H1954-002.1.iraf

Most of the hard work is done by the "dohydra" routine, which will (optimally) extract your spectra, do the necessary wavelength calibration and sky subtraction, but some preliminary processing is necessary:

load the noao.imred.ccdred package

setinstrument fibers

zerocombine n19*.imh output=Zeron19

ccdproc n19002*.imh fix- overscan+ trim+ zerocor+ biassec=[1:32,2:2046] trimsec=[33:2080,2:2046] zero=Zeron19

flatcombine n190027,n190028,n190029 output=Flatm33fld2 reject=avsigclip scale- rdnoise="NOISE_12" gain="GAIN_12"

Note that the trim section is a little different than the default suggested in the image header.

One is now dealing with the following dataset:

- combined dome flat: Flatm33fld2
- single comparison: n190026

- object frames: n190023, n190024, n190025
- the ".iraf" file H1954-002.1.iraf

The parameters for "dohydra" are given in Fig. 1. The only parameters that have been changed from their defaults is the read-noise, gain, and number of fibers—this has been changed to 98 to make the fiber identification easier.

```
objects = n190023,n190024,n190025  List of object spectra
(apref  =          Flatm33fld2) Aperture reference spectrum
(flat   =          Flatm33fld2) Flat field spectrum
(through=                     ) Throughput file or image (optional)
(arcs1  =              n190026) List of arc spectra
(arcs2  =                     ) List of shift arc spectra
(arcrepl=                     ) Special aperture replacements
(arctabl=                     ) Arc assignment table (optional)
(readnoi=                 4.5) Read out noise sigma (photons)
(gain   =                 1.7) Photon gain (photons/data number)
(datamax=               INDEF) Max data value / cosmic ray threshold
(fibers =                  98) Number of fibers
(width  =                12.) Width of profiles (pixels)
(minsep =                 8.) Minimum separation between fibers (pixels)
(maxsep =                15.) Maximum separation between fibers (pixels)
(apidtab=     H1954-002.1.iraf) Aperture identifications
(crval  =               INDEF) Approximate central wavelength
(cdelt  =               INDEF) Approximate dispersion
(objaps =                   ) Object apertures
(skyaps =                   ) Sky apertures
(arcaps =                   ) Arc apertures
(objbeam=                  1) Object beam numbers
(skybeam=                  0) Sky beam numbers
(arcbeam=                   ) Arc beam numbers
(scatter=                  no) Subtract scattered light?
(fitflat=                 yes) Fit and ratio flat field spectrum?
(clean  =                 yes) Detect and replace bad pixels?
(dispcor=                 yes) Dispersion correct spectra?
(savearc=                 yes) Save simultaneous arc apertures?
(skyalig=                  no) Align sky lines?
(skysubt=                 yes) Subtract sky?
(skyedit=                 yes) Edit the sky spectra?
(savesky=                 yes) Save sky spectra?
(splot  =                  no) Plot the final spectrum?
(redo   =                  no) Redo operations if previously done?
(update =                 yes) Update spectra if cal data changes?
(batch  =                  no) Extract objects in batch?
(listonl=                  no) List steps but don't process?
(params =                   ) Algorithm parameters
(mode   =                  ql)
```

Figure 1: Parameters for dohydra.

```
(line   =               INDEF) Default dispersion line
(nsum   =                  10) Number of dispersion lines to sum or median
(order  =          decreasing) Order of apertures
(extras =                  no) Extract sky, sigma, etc.?

                               -- DEFAULT APERTURE LIMITS --
(lower  =                -5.) Lower aperture limit relative to center
(upper  =                 5.) Upper aperture limit relative to center

                               -- AUTOMATIC APERTURE RESIZING PARAMETERS --
(ylevel =               0.05) Fraction of peak or intensity for resizing

                               -- TRACE PARAMETERS --
(t_step =                  10) Tracing step
(t_funct=             spline3) Trace fitting function
(t_order=                   3) Trace fitting function order
(t_niter=                   1) Trace rejection iterations
(t_low  =                  3.) Trace lower rejection sigma
(t_high =                  3.) Trace upper rejection sigma

                               -- SCATTERED LIGHT PARAMETERS --
(buffer =                  1.) Buffer distance from apertures
(apscat1=                    ) Fitting parameters across the dispersion
(apscat2=                    ) Fitting parameters along the dispersion

                               -- APERTURE EXTRACTION PARAMETERS --
(weights=                none) Extraction weights (none|variance)
(pfit   =               fit1d) Profile fitting algorithm (fit1d|fit2d)
(lsigma =                  3.) Lower rejection threshold
(usigma =                  3.) Upper rejection threshold
(nsubaps=                   1) Number of subapertures

                               -- FLAT FIELD FUNCTION FITTING PARAMETERS --
(f_inter=                 yes) Fit flat field interactively?
(f_funct=             spline3) Fitting function
(f_order=                  10) Fitting function order
```

Figure 2: The parameter set "params" (continued on the next page).

The algorithm parameters are shown in Fig. 2 and 3. The only parameters that have been changed from their default values are the trace parameters and the arc identification line list. Note that although the weights under the extraction method says "none", variance weighting will indeed be used since "clean" was specified in the "dohydra" parameters.

```
                            -- ARC DISPERSION FUNCTION PARAMETERS --
(thresho=                  10.) Minimum line contrast threshold
(coordli=   linelists$cuar.dat) Line list
(match  =                  10.) Line list matching limit in Angstroms
(fwidth =                   4.) Arc line widths in pixels
(cradius=                  10.) Centering radius in pixels
(i_funct=              spline3) Coordinate function
(i_order=                    3) Order of dispersion function
(i_niter=                    2) Rejection iterations
(i_low  =                   3.) Lower rejection sigma
(i_high =                   3.) Upper rejection sigma
(refit  =                  yes) Refit coordinate function when reidentifying?
(addfeat=                   no) Add features when reidentifying?

                            -- AUTOMATIC ARC ASSIGNMENT PARAMETERS --
(select =               interp) Selection method for reference spectra
(sort   =                   jd) Sort key
(group  =                  ljd) Group key
(time   =                   no) Is sort key a time?
(timewra=                  17.) Time wrap point for time sorting

                            -- DISPERSION CORRECTION PARAMETERS --
(lineari=                  yes) Linearize (interpolate) spectra?
(log    =                   no) Logarithmic wavelength scale?
(flux   =                  yes) Conserve flux?

                            -- SKY SUBTRACTION PARAMETERS --
(combine=              average) Type of combine operation
(reject =            avsigclip) Sky rejection option
(scale  =                 none) Sky scaling option
(mode   =                   ql)
```

Figure 3: The rest of the parameter set "params".

Upon running dohydra, you will first be presented with the aperture identifications of the 97 fibers. Check to see that there are gaps (no fiber identified) at 58 and 75 for the blue fiber cable (or check your ".iraf" file for the current "Gap" locations. For the red cable, make sure that the gap corresponds to the (non-existent) fiber number 68. (Fiber 2 will be the first fiber in each case. You may have to play with "i", "o", and "m" to make this all work. But, this is a critical step!) See Figure 4.

Next, you will be presented with the traces of the flat-field exposures. A typical trace and fit is shown in Figure 5

You will be presented with the fit of the "average" flat-field extraction; this is shown in Figure 6.

In the next step the comparison spectrum will be extracted, and you will be given a chance to run the normal "identify" routine on it. Mark ("m") several lines whose wavelength identification you are certain of. You can generate a new fit using "f". A typical identification and good fit are shown in Figure 7.

The program will then go through and extract and wavelength calibration the individual spectra from the program frames. After this step, you will be presented with a chance to edit (delete) sky spectra before sky subtraction. A sample sky spectrum (before and after a little judicious editing) is shown in Figure 8.

After this procedure is repeated for each of the program frames, we find ourselves with three "multislit" spectra n190023.ms, n190024.ms, and n190025.ms.imh. These can now be combined using "scombine" as follows:

scombine n1910023.ms,n1910024.ms,n1910025.ms out=m33.ms.imh

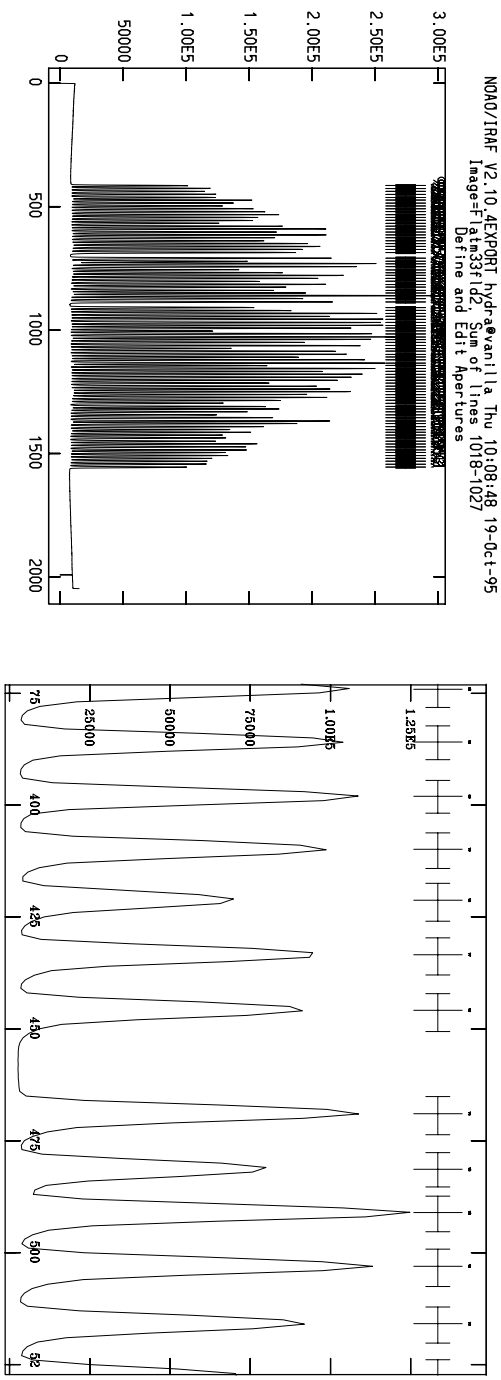

Figure 4: The aperture identifications are shown.

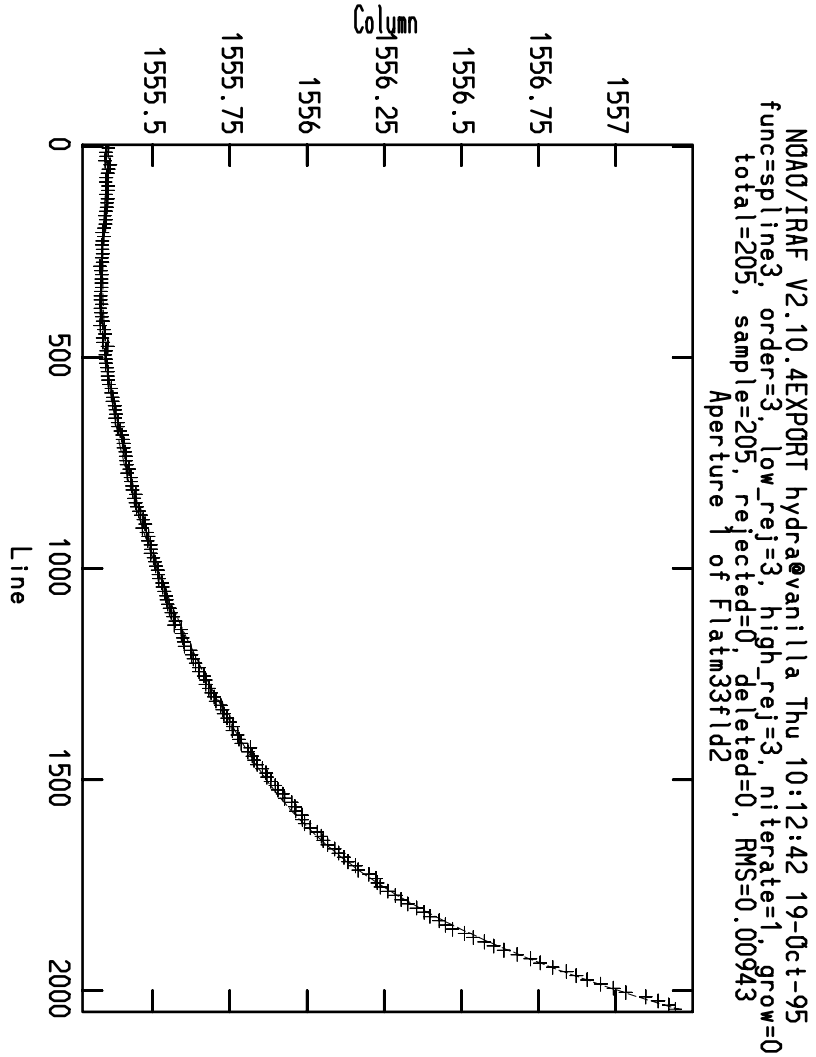

Figure 5: The trace of the flat-field reference.

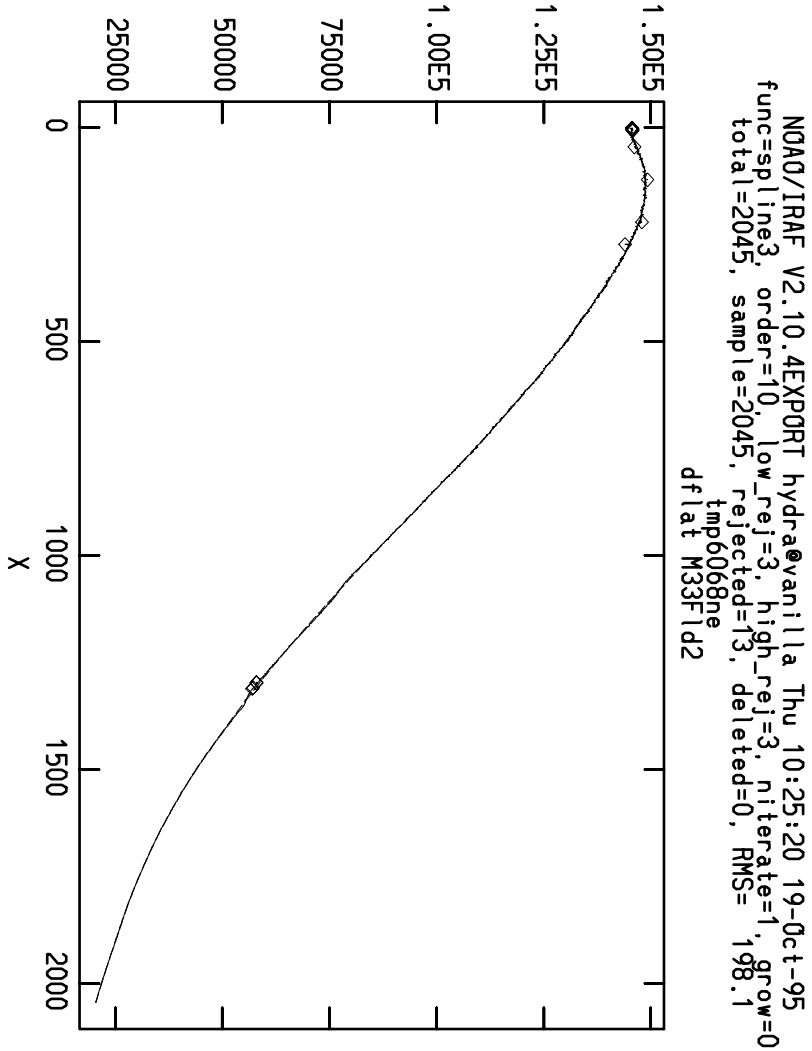

Figure 6: The fit of the averaged flat-field extraction is shown.

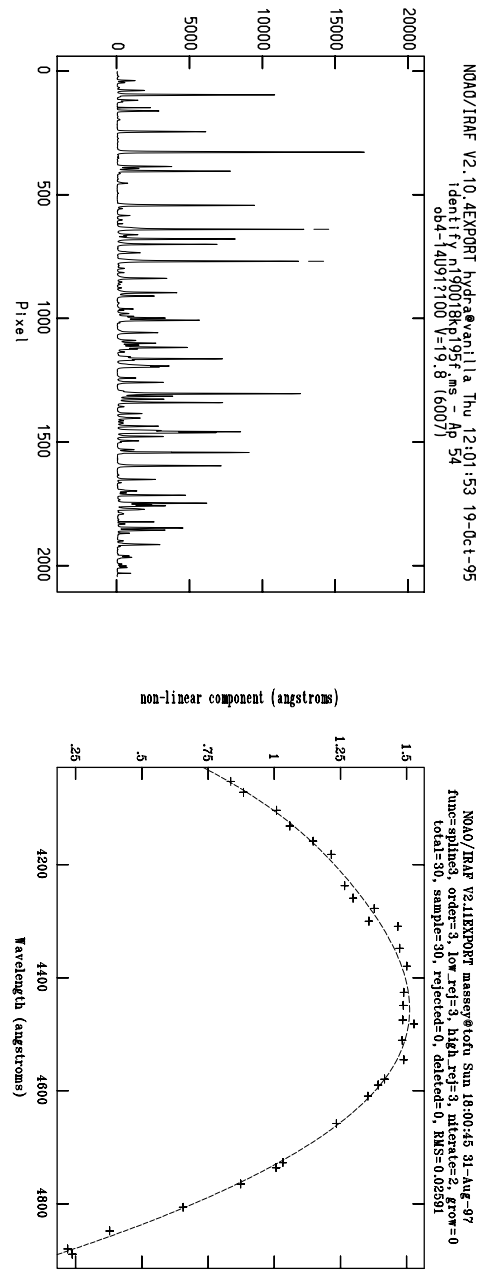

Figure 7: The wavelengths identifications are shown.

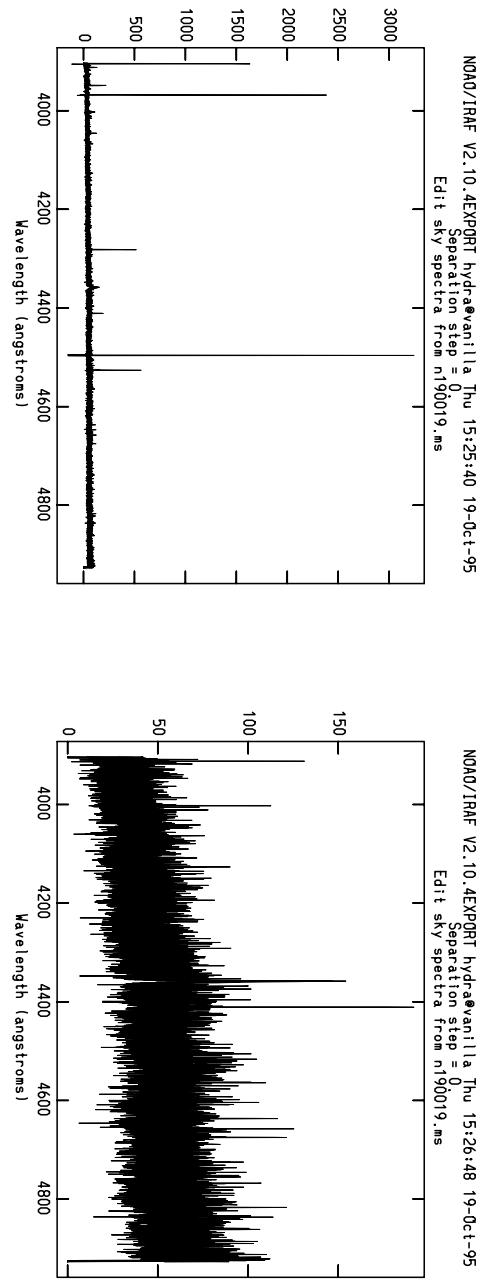

Figure 8: The most deviant skys, and the ones with the worst cosmic rays, have been deleted using the "d" key; a replot ("r") is shown in the bottom pannel.