IRAF AND SPECTRA REDUCTION (BASICS)

GENERAL AND USEFUL INFO Information and books in http://iraf.net/irafdocs/

See also tutorials http://iraf.noao.edu/tutorials/tutorials.html

I strongly suggest and thank http://www.faculty.virginia.edu/ASTR5110/assignments.html

Practicum V (Sep. 22): Introduction to IRAF iraf_v5.0.pdf

Practicum XI (Nov. 17): Reducing CCD Data/IRAF's CCDPROC Routine http://www.faculty.virginia.edu/ASTR5110/lectures/detectors/detectors_red.html VirginiaCCD.pdf

Practicum VIII (Oct. 20): Working with Spectra (IRAF onedspec, twodspec, apextract packages) with http://www.faculty.virginia.edu/ASTR5110/lectures/spectroscopy/spec.html VirginiaSpettroscopia.pdf

THe file spiegaIRAF.text (by Girardi+Boschin) gives help, too, but it is in Italian language.

See also http://www.twilightlandscapes.com/IRAFtutorial/IRAFintro_06.html

I assume that you know the first parts of Prac VIII and XI from lectures of Prof.Cristiani and we will make a practicum to make the reduction of a spectrum.

HEREBELOW the points to make the reduction of MOS spectra acquired at NTT

PHASE 0

* give a look at the fits of your observations using ds9

and copy the fits of your observations in files with easier names

e.g. MOS1Flat1.fits.gz … USE the log of your observations for this!!!

* organize in lists

ls MOS1Flat* > flat.list

ls MOS1Lamp* > lamp.list

ls MOS1Spec* > spec.list

ls Bias* > bias.list

NOTE1 We have sky FF and standard stars calibration, but we will not use …

NOTE2 instead of xterm/ds9 you can also use xgterm ds9 iraf display

START WITH IRAF

source .bashrcsalva (or whatever you have to make run iraf)

cd iraf

xgterm   NOTE:make the window longer!!!!

ds9 &

set stdimage=imt8192 (or maybe you have inside your login.cl ?)

cl

VERY IMPORTANT – UPARM DIR

mkdir uparmsave

the first time use task with default param

and cp the file.par in uparmsave

then change the file.par if you need

VERY IMPORTANT – DATABASE

Both apall and identify produce files in /database. If you want to remake a trace aperture
or idenfication withe lamps, you have to destroy the relevant files in /database

CCD REDUCTION

PHASE 1 combine images...

%epar imcombine -> median

@bias.list -> Bias.fits

@flat.list -> flat.fits

@lamp.list -> Lamp.fits

NOTE1 use epar, at "combine" write ? ....you will see your possibilities...write median

NOTE2 the second time, you can launch imcombine and give a different name for files....VERY RISKY, I prefer to re-use epar..

NOTE3 indeed, it is best to use average for images not affected by cosmics and median only for those affected by cosmics (since with avg you reduce error of sqrt(n), see Virginia CCD lectures too...). However for the spectroscopy here this is not important (other are the sources of the problems...calibration...tracing the spectra and so on), for photometry is important (and other tasks are used with sigma clipping and so on – see Virginia lectures).

PHASE 2 subtract the bias

CREATE A LIST OF NAMES Spec.list with Spec1.fits,Spec2.fits,..

cp spec.list Spec.list and change the names!!!

%epar imarith

@spec.list - Bias.fits = @Spec.list

@flat.fits - Bias.fits = Flat.fits

PHASE 3 extract/cut the single spectrum from the whole image

(ONLY FOR MOS, not necessary for LONGSLIT)

SELECTS COORDINATES TO CUT

%epar display Spec1.fits   ....to be sure to see the whole image...

%imexamine ...go to ds9 window

select one spectrum and select two extreme points to cut (diagonal)

USE "x" to cut

the coordinates will appear on the screen...

x1 y1 l1

x2 y2 l2

q   to exit

save the numbers them in a file cutmos1.list (use mouse+emacs/editor)

NOTE: THE NUMBERS ARE NO DECIMAL!!!

...NOTE: alternatively epar imexamine...and work with it

CHECK

%epar tvmark ...put cutmos1.list in the coords...if needed change the "size" of points

Using cutmos1.list CREATE a list of files to be cut and the files post cut

input.list and output.list

```
Spec1.fits[459:2063,1863:1904]
Spec1.fits[149:2063,1788:1835]
Spec2.fits[459:2063,1863:1904]
Spec2.fits[149:2063,1788:1835]
Spec3.fits[459:2063,1863:1904]
Spec3.fits[149:2063,1788:1835]
Spec4.fits[459:2062,1863:1904]
Spec4.fits[149:2063,1788:1835]
Lamp.fits[459:2063,1863:1904]
Lamp.fits[149:2063,1788:1835]
Flat.fits[459:2063,1863:1904]
Flat.fits[149:2063,1788:1835]
```

```
Spec1.sl01.fits
Spec1.sl02.fits
Spec2.sl01.fits
Spec2.sl02.fits
Spec3.sl01.fits
Spec3.sl02.fits
Spec4.sl01.fits
Spec4.sl02.fits
Lamp.sl01.fits
Lamp.sl02.fits
Flat.sl01.fits
Flat.sl02.fits
```

CUT

%epar imcopy

@input.list @output.list

CHECK e.g. ds9 Spec1.sl01.fits

PHASE 4 to make flat correction

Normalizing the flats. Now that we have combined flats we have to normalize them for spectroscopic use, when viewing the flats you'll notice that they include peaks and troughs along lines but that they all follow a much larger scale wave like structure, we wish to remove this large structure so that we spread the smaller peaks and troughs over a flat surface. (Note that this large structure arises for many reasons for example in domeflats it could be due to the reflectivity of the surface you are shining light upon). Response allows you to fit a spline across the flat data and normalize it accordingly (note: the other reason we normalize is because flat counts are normally so high that any flat division of images results in a very badly defined image, so we want to have the average of the flats being 1 so that we keep count rates on the images roughly the same).

CREATE from output.list and Flat.list   …. Flat.sl01.fits and from this a Flatn.list … Flat.sl01n.fits …

%noao

%twodspec

%longslit

%epar response

@Flat.list

@Flat.list

@Flatn.list

put order 10 and :go

you will see the fit the first, click on the window and exit with q and go on

in the case you made with order 1 (the default…the fit is bad!!!) click on the window and exit with q and go on

CHECK cfr Flat.sl01.fits and Flat.sl01n.fits

CREATE   a list of Spec to be flatted   daflat.list = output.list ONLY Spec
a list of flatting operator opflat.list wich is = Flatn.list but corresponding to daflat.list
a list of flatted Spec flatted.list (sim to daflat but with name Spec1.sl01f.fits)

%epar imarith

@daflat.list / @opflat.list = @flatted.list

CHECK/GIVE A LOOK to a few flatted Spec1.sl01f.fits

PHASE 5 COSMETICS!!!

CREATE a precosmic.list and a cosmic.list (=flatted.list but ONLY ONE slit)

Spec1.sl01f.fits
Spec2.sl01f.fits
Spec3.sl01f.fits
Spec4.sl01f.fits
-> and Spec1.sl01fC.fits … in output

%epar imedit

@precosmic.list   @cosmic.list

work on ds9 window

if cosmics far from spectar and line   "b"

if you are near/close a line

  c

l   l   to fit in col and line

  c

if inside spectrum leave them there

u = UNDO

q exit or ll spec

CLEAN FROM COSMICS IN LAB FOR STUDENTS …VERY TIME CONSUMING!!!!

ALTERNATIVE A good alternative is imcombine Spec1.sl01f.fits Spec2.sl01f.fits Spec3.sl01f.fits Spec4.sl01f.fits with the median and obtain Spec.sl01.fit

The advantage is that you can make a better "trace" BUT you have to be sure that your images are not shifted (e.g. due to flexions of the telescope in the night). In the case you are not sure, the best it is to calibrate each image with a very close-time Lamp…than check, eventually shift and combine at posteriori the spectra.

CLEAN FROM BAD LINES

… prepare a badpix.sl??.list

47 47 133 488 will put away the 47th col from 133 to 488 line

%epar fixpix

@cosmic.list

IT WRITES OVER!!! OR CREATE ANOTHER LIST….(OR SAVE GOOD *C.fits somewhere)

At the end you will have a Spec1.sl01fC.fits or a

combined Spec.sl01f.fits and Spec.sl02f.fits or whatever

SPECTRA REDUCTION

for NTT spectra which are horizontal: %hedit Spec.sl02f.fits DISPAXIS 1 add+

and see also specific commands along the procedure...

SIMPLIFIED (1D) procedure

PHASE 6 SET AND TRACE APERTURES

%noao

%twod

%apex

%apextract.dispaxis=1 (if spectra are horiz)

%epar apall with Spec.sl02f.fits and onedspec....put always "yes" for trace the aperture

%:go

l and q to make better the left and right limits of the aperture (rather than the predefined one)

b to go to the background, z to cancel predefined background

s and s ..... a and s.... f   to make a better background and to fit it

q to come back at the aperture

q to say that it is ok...then reply yes yes yes...to trace extract and write the aperture...

you will obtain Spec.sl02.0001.fits and aperture inside database

%epar apall with   Lamp.sl02.fits and Spec.sl02 as ref. and put yes for run/edit/extract the aperture

you will obtain Lamp.sl02.0001.fits and aperture inside database

PHASE 7 identify lines in the LAMP

give a look in the fits, your Lamp is a cal-MOS_1-4-He+Ar+Ne, use the plot He-Ar of the teacher or take from ESO

mkdir /iraf/database if you do not have

%noao

%onedspec

%epar identify   with Lamp.sl02.0001.fits

select by eye for 5-6 lines inthe whole range

m

write lambda value

return

f show the fit

you can use d to delete a line which is far from the fit

k and l to change the fit, linear is ok

q come back to the spectrum

e design all lines using REFS lines (d the lines you do not see)

f and so on...when RMS<sim 1 it is OK (<<1 is strange...you do not need)

q

q

save? yes

NOTE: try to use X,Y,Z to zoom … r to go to original ...before to use m

NOW in the database you have idLamp.sl01

if you want/have to to remake, please delete it!!!

PHASE 8 and 9 CALIBRATION

%epar refspectra   with Spec.sl02.0001 and Lamp.sl02.0001 and put match

Better to make too: %hedit Spec.sl02.0001.fits REFSPEC add+ value="Lamp.sl02.0001"

%epar dispcor with Spec.sl02.0001 and output with Spec.sl02l.0001

PHASE 10 COSMETICS again

%splot Spec.sl02l.0001

put away bad sky extraction, cosmics...

a and a to zoom

x and x to put away or j and j to fill

r to redraw

c to unzoom

i to save with a name e.g. Spec.sl02l.0001x.fits

...when you are satisfied (look at the absline at 7600A is due to the sky!)

 :.snap epsfile to print in a sgi*.eps file   or use =

IN THE CASE OF MANY: SPEC1 SPEC2 SPEC3...

%specplot to see all of them

correct for the x-shift if necessary and then combine them...

PHASE 11   z determination

to make a rough redshift measure

%splot Spec.sl02l.0001x.fits

k and k to have the center lambda->z lambdaOSS/lambdaLAB=1+z

MUCH BETTER, USE THE TASK!

%rvaso

%epar xcsao   with Spec.sl02l.0001x.fits

herebelow something to change (mgirardi=your username)

specdir,s,h,"/home/mgirardi/iraf/",,,"Directory for input spectra"

correlate,s,h,"velocity",|velocity|wavelength|pixel|yes|no|,,"Cross-correlate   spectrum (velocity wavelength pixel no)"

templates,s,h,"@/home/mgirardi/iraf/template/kennt",,,"List of template spectra"

tempdir,s,h,"/home/mgirardi/iraf/template/",,,"Directory for template spectra"

st_lambda,r,h,4000.,,,"Starting wavelength in Angstroms or pixels to correlate"

end_lambda,r,h,7000.,,,"Ending wavelength in Angstroms or pixels to correlate"

badlines,s,h,"badlines.dat",,,"Lines to eliminate from spectrum"

interp_mode,s,h,"spline3",nearest|linear|spline3|poly3|poly5|sums,,"Rebin   interpolation mode"

vel_init,s,h,"zero",zero|guess|zguess|correlation|emission|combination,,"Initial   velocity source (zero guess zguess corr em comb)"

czguess,r,h,0.,,,"Initial velocity guess in km/sec or z"

minvel,r,h,0.,,,"Minimum allowable velocity in km/sec"

maxvel,r,h,80000.,,,"Maximum allowable velocity in km/sec"

ablines,s,h,"ablines.dat",,,"Absorption line list"

emlines,s,h,"emlines.dat",,,"Emission line list"

linedir,s,h,"/home/mgirardi/iraf/",,,"Directory for line lists"

dispmode,i,h,1,,,"Display modes (1=spectrum+xcor 2=spectrum+lines)"

vel_plot,s,h,"correlation",correlation|emission|combination,,"Velocity to plot"

ALTERNATIVE METHOD FOR SPECTRA REDUCTION

PHASE 6/7/8/9 WORKING IN 2-D   (USEFUL WHEN THE SLIT IT IS NOT RIGHT)

PHASE 6a identify lines in the LAMP

as above

%noao

%onedspec

%epar identify with e.g. Lamp.sl01.fits

NOW in the database you have idLamp.sl01

VERY IMPORTANT !!!! for NTT where the spectra are horizontal!!!

%set dispaxis=1

PHASE 6b TO PREPARE COORDINATE TO MOVE X-AXIS IN LAMBDA!

%noao

%two

%long

%epar fitcoords

Lamp.sl01

chebyshev

VERY IMPORTANT !!!! for NTT where the spectra are horizontal!!!

Xorder: 6

Yorder: 2

:go

yes

….eventually d p to delete some points

q

save

NOW in the database, you will have fcLamp.sl01

Here we work with Spec1.sl01fC.fits i.e. The first spectrum corrected for cosmics

PHASE 7 to associate lambda to X-axis

CREATE list trasf.list with Spec1.sl01fCt.fits

%noao

%two

%long

%epar trasform

@cosmic.list

@trasf.list

fitnames....put Lamp.sl01

answer 1 for dispaxis

cfr Spec1.sl01fC.fits and Spec1.sl01fCt.fits now you have lambda!!!!

PHASE 8 correction of the background

CREATE list back.list with Spec1.sl01fCtb.fits

%noao

%two

%long

%epar background

@trasf.list

@back.list

axis 2

niteration 0

:go

give the number of a line where you see the spectra e.g. 975

 s s   and s s in the two sides to fix the backgroud

f to fit

is it ok?

q

q

you can fit only one side...

cfr Spec1.sl01fCt.fits and Spec1.sl01fCtb.fits....most sky lines are disappeared

PHASE 9 to fix aperture and extract spectrum

CREATE apall.list the same of back.list without .fits

%noao

%two

%apex

@back.list

@apall.list

onedspec

no...extract sky

nsum 40

:go

number of aperture? 1 (2 is more difficult!!!)

in the irafterm as before....

NOW you have Spec1.sl01fCtb.0001.fits IT IS in LAMBDA!!!

PHASE 10 and 11

"COSMETICS AGAIN" and "REDSHIFT DETERMINATION" as before