

# **ASTRONOMY LAB: Session I (IRAF)**

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## **Installation**

Since I am using windows so in order to use IRAF I installed windows subsystem for linux (wsl) from where we can install and use all linux softwares and features. In that I have successfully installed xgterm, ds9 and IRAF. Xgterm is not that user friendly so I am also looking for ways into it for my own convenience.

I have to open wsl terminal from there then xgterm terminal. After that I went to the file location where the login.cl file is there and then open IRAF by writing the command cl. Also by writing the linux command inside it !ds9 & so that ds9 will open and the terminal remain usable this whole process is done. Now it is ready to use for any sort of image analysis.

## **Exploring Images in DS9**

The most interesting thing that I think is there are the alphabets that we can push to see nearby pixel values, various kind of plots, statistics etc. So even though it was only asked for few of them, I have added other things too.

Using epar display we can change the settings/parameters of the images we want to open. I changed scale to log and while opening from ds9 also (the same image as asked in the question) I converted the scale to log for proper conversion.

```
satyapriya@DESKTOP-K3HE86Q:~$ ls
First_Task_IRAF      iraf-2.17.1.zip
build.log            iraf-2.17.1.zip:Zone.Identifier
ds3.ubuntu20.8.5.tar.gz  upara
For_ds3              x11iraf-2.1
iraf                 x11iraf-2.1.tar.gz
iraf-2.17.1          x11iraf-2.1.tar.gz:Zone.Identifier
satyapriya@DESKTOP-K3HE86Q:~$ cd iraf-2.17.1
satyapriya@DESKTOP-K3HE86Q:~/iraf-2.17.1$ ls
CITATION.cff  Makefile  bin  doc  licenses  noao  unix
COPYRIGHT    README.contents  bin.linux64  extern  local  pkg  vendor
CREDITS.md   README.md  build.log  include  math  sys

Community IRAF V2.17.1

This product includes results achieved by the IRAF64 project in 2006-2008 directed by Chisato Yamauchi (C-SORA/ISAS/JAXA).

Welcome to IRAF. To list the available commands, type '?' or '?. To get
detailed information about a command, type 'help <command>'. To run a
command or load a package, type its name. Type 'bye' to exit a
package, or 'logout' to get out of the CL.

Visit http://iraf.net if you have questions.

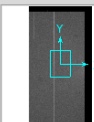
*** Using global login file: /home/satyapriya/iraf/login.cl
The following commands or packages are currently defined:

    dataio.  language.  noao.    plot.    softools.  utilities.
    images.  lists.    obsolete. proto.    system.

cl> lds9 &
cl> ls
LAB_1.pdf  photo1.fits  photo2.fits  test-f1.fits  test-f2.fits
cl> inxamine test-f2.fits
display frame (1): (1):
z1=554, z2=6730,738
[]
```

**SAOImage ds9**

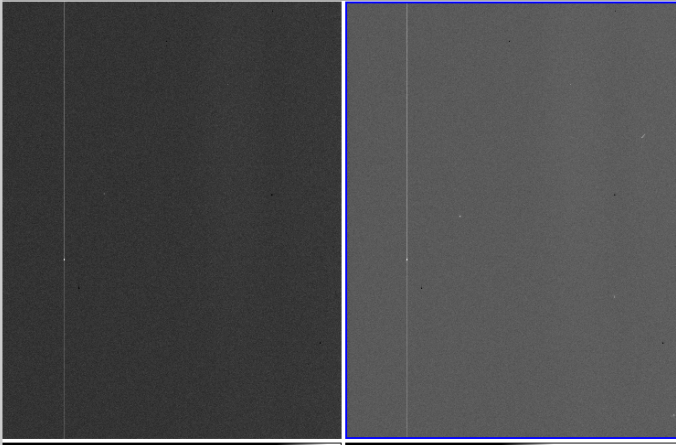
File Edit View Frame Bin Zoom Scale Color Region WCS Illustrate Analysis Help

File: test-f2.fits  
Object: unnamed  
Value: 169  
WCS: 

Physical: x 573 y 1232  
Image: x 254 y 413  
Frame 1: x 1 y 0 \*

file edit view frame bin zoom scale color region wcs illustrate analysis help

linear log power sqrt squared asinh sinh histogram min max zscale



```

? Help          h Histogram      p Previous frame  x Coordinates
a Aperture Sum  i Image cursor   q Quit           y Set origin
b Box coords    j Line gauss fit r Radial plot    z Print grid
c Column plot   k Col gauss fit  s Surface plot   , Quick phot
d Load display l Line plot      t Output image   . Quick prof fit
e Contour plot  m Statistics     u Vector plot
f Redraw        n Next frame    v Vector plot
g Graphics cursor o Overplot       w Toggle logfile

COLON COMMAND SUMMARY

allframes  ceiling  iterations  naverage  pointmode  width
angh       center  label      nbins     radius     x
angv       constant logfile      ncolumns  round      xformat
autoredraw dashpat  logx       ncontours rplot      xlabel
autoscale  defkey   logy       ncoutput  select     xorder
background eparam   magzero    ncstat    szmarker   y
banner     fill    majrx      nhi       ticklabel  yformat
beta       fitplot majry      nlines    title      ylabel
boundary   fittype marker     nloutput  top_closed yorder
box        floor   minrx      nlstat    unlearn    z1,z2
buffer     interval minry      output    wcs        zero

OUTPUT OF 'a' AND 'r' KEYS

The 'a' key and logfile output has column labels and each object has one
line of measurements in the logfile and two lines on the terminal. The 'r'
key shows only the second line on the status line and the information from
the first line is in the graph title. The first line contains the x and y
center coordinates and optional world coordinates. The second line
contains the aperture magnitude and flux, the estimated background sky, the
profile fit peak, the ellipticity and position angle from the moment
analysis, and four estimates of the profile width. The four estimates are
from the moment analysis, the full-width enclosing half the flux, the
profile fit, and a direct estimate of the full width at half-maximum.

CURSOR KEY COMMANDS

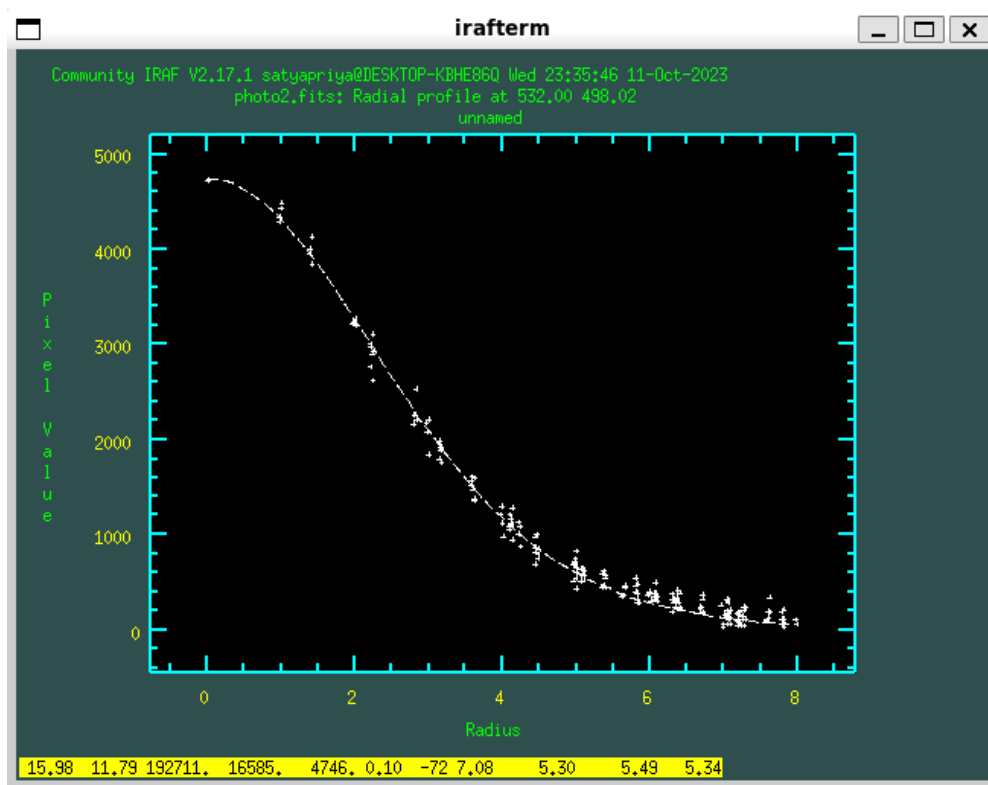
?      Print help
a      Aperture radial photometry measurement (see above for output)
b      Box coordinates for two cursor positions - c1 c2 l1 l2
c      Column plot
d      Load the image display
e      Contour plot
f      Redraw the last graph
g      Graphics cursor
h      Histogram plot
i      Image cursor
j      Fit 1D gaussian to image lines

```

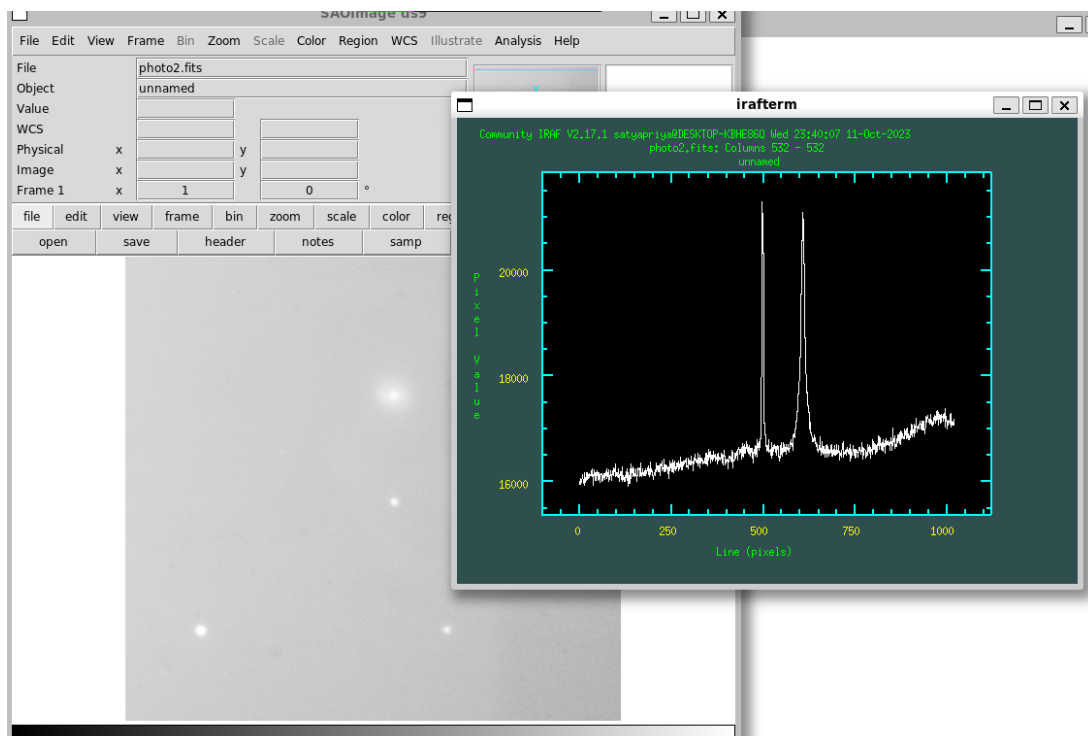
This shows the help one. Really HELPful since we don't have to remember anything. But anyway it is quite intuitive too.

Below for a star(I have marked in one figure which one) I have added all the corresponding figures and values as asked (and beyond).

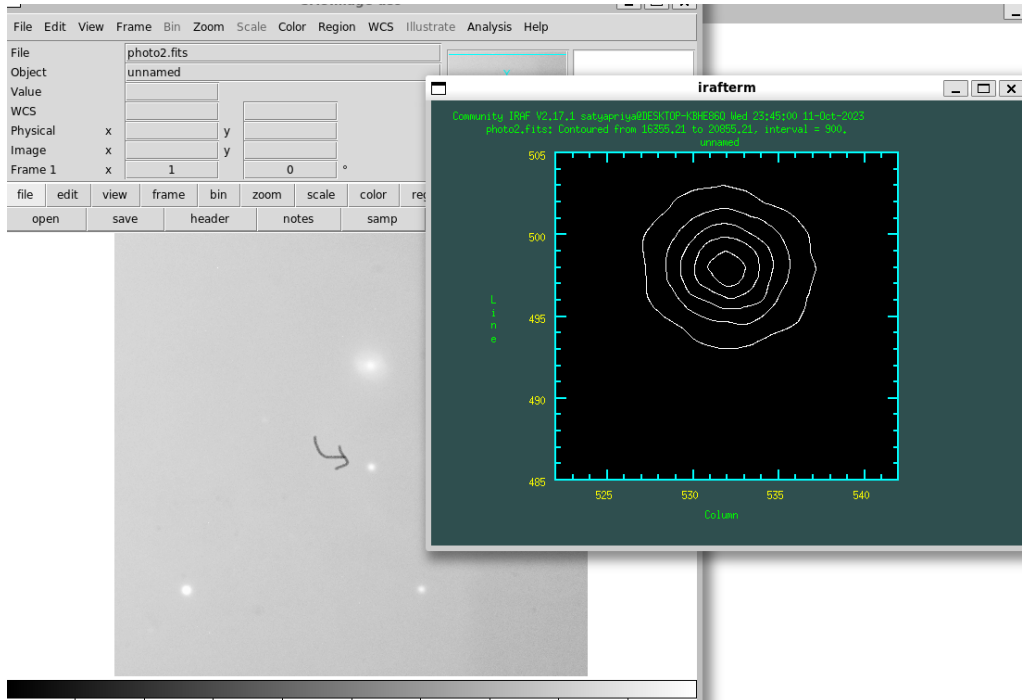
**r- gives radial profile of a source**



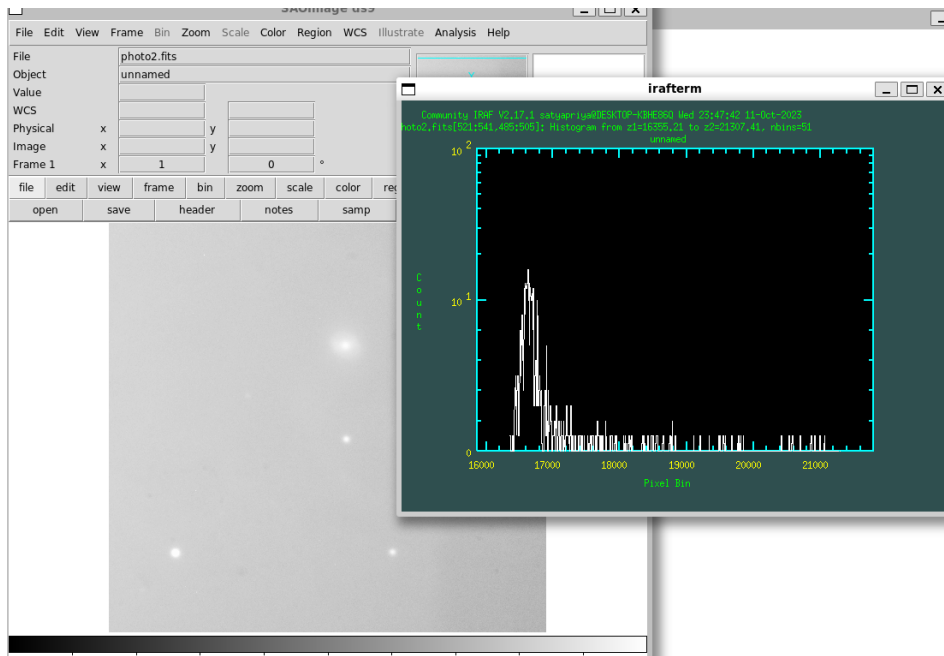
**c - Column plot across those two stars**



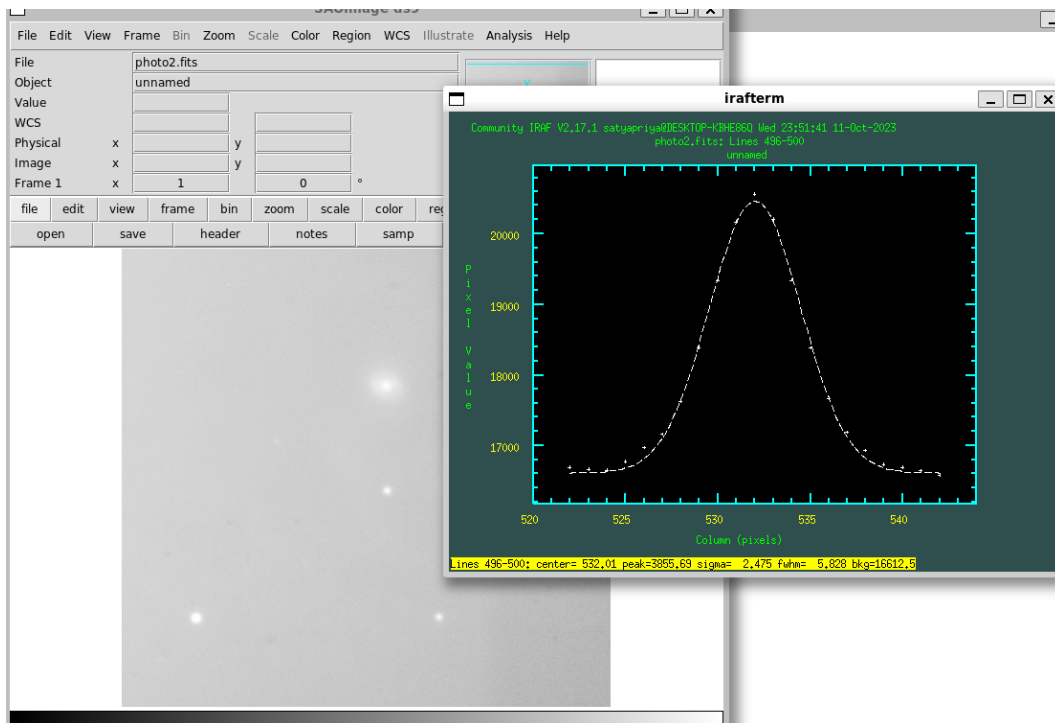
## e – contour plot



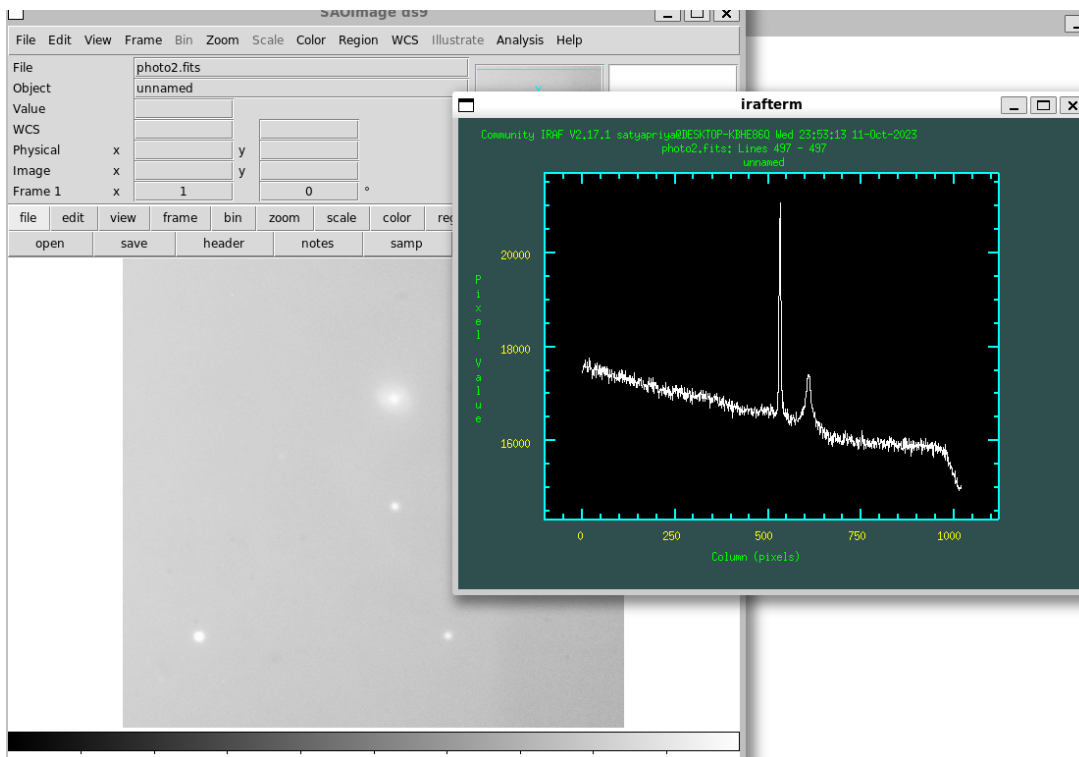
## h – histogram plot



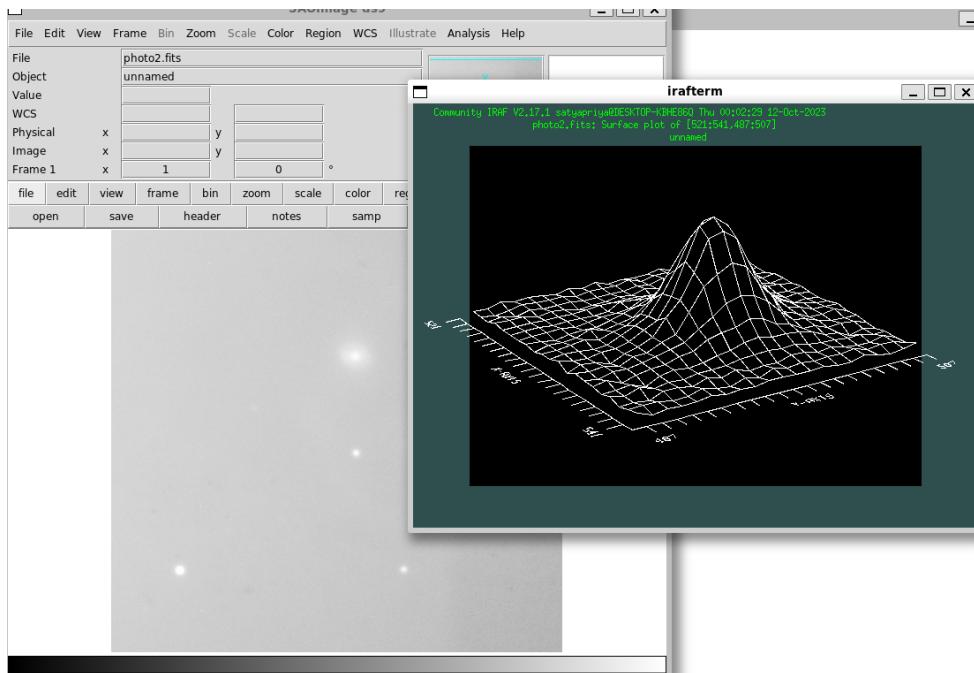
## j – line gauss fit



## l – line plot



## s - surface plot



a (aperture sum) gives:

```
# COL LINE COORDINATES
# R MAG FLUX SKY PEAK E PA BETA ENCLOSED MOFFAT DIRECT
532.00 498.02 532.00 498.02
15.98 11.79 192711. 16585. 4746. 0.10 -72 7.08 5.30 5.49 5.34
```

m(statistics):

```
# SECTION NPIX MEAN MEDIAN STDDEV MIN MAX
_ [529:533,496:500] 25 19731. 19679. 981.9 17953. 21307.
```

Z(nearby value):

```
WARNING: CLOSING WINDOW TO 1.
527 528 529 530 531 532 533 534 535 536 537
502 1.7E4 1.7E4 1.7E4 1.7E4 1.8E4 1.8E4 1.8E4 1.7E4 1.7E4 1.7E4
501 1.7E4 1.7E4 1.8E4 1.8E4 1.9E4 1.9E4 1.8E4 1.8E4 1.8E4 1.7E4
500 1.7E4 1.8E4 1.8E4 1.9E4 2.0E4 2.0E4 1.9E4 1.9E4 1.8E4 1.7E4
499 1.7E4 1.8E4 1.9E4 2.0E4 2.1E4 2.1E4 2.1E4 2.0E4 1.9E4 1.8E4
498 1.7E4 1.8E4 1.9E4 2.0E4 2.1E4 2.1E4 2.1E4 2.0E4 1.9E4 1.8E4
497 1.7E4 1.8E4 1.9E4 2.0E4 2.0E4 2.1E4 2.1E4 1.9E4 1.8E4 1.8E4
496 1.7E4 1.7E4 1.8E4 1.9E4 1.9E4 2.0E4 2.0E4 1.9E4 1.8E4 1.8E4
495 1.7E4 1.7E4 1.7E4 1.8E4 1.8E4 1.8E4 1.8E4 1.8E4 1.8E4 1.7E4
494 1.7E4 1.7E4 1.7E4 1.7E4 1.8E4 1.8E4 1.8E4 1.7E4 1.7E4 1.7E4
493 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4
492 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4 1.7E4
```

## Exercise:

1. Display 'test-f2.fits' from IRAF environment in buffer #1 and then open the same image in frame #2 using ds9. What is the difference? (You might have to set stdimage. Check your notes).

The header is not the same. When loaded from imexamine it shows only this in header:

```
SIMPLE =          T / Fits Standard
BITPIX =          8 / Bits per pixel
NAXIS  =          2 / Number of axes
NAXIS1 =         4096 / Axis Length
NAXIS2 =         4096 / Axis Length
END
```

Whereas loading from ds9 it shows full information in header. Also in image opened from display doesn't show the option to change scale, illustrate, icons in view in ds9.

2. Where was this image taken, with what size of a telescope, and with what instrument and detector?

```
TELESCOP= 'APO 3.5m      ' / Telescope used for observation
ORIGIN   = 'Apache Point Obser' / Observatory Location
LATITUDE=      32.780361 / Observatory Latitude (degrees)
LONGITUD=     105.820417 / Observatory longitude (degrees)
INSTRUME= 'Spicam      ' / Instrument used for observation
DETECTOR= 'Spicam CCD   ' / Detector used for observation
```

3. On what date was the observation made? How long was the exposure?

```
DATE-OBS= '99/03/11      ' / local date of obs   (I think it is 11th March 1999)
EXPTIME  =      5.000000 / actual exposure time  (No unit given (Problem!!))
```

4. We define a 'frame' as entire read-out from the CCD (including any overscan region) and 'image' as that portion of the 'frame' that has the observation. How many pixels are there in the entire image? Is this value consistent with the results obtained in 'imstat'? Explain.

```
> imstat
_list of input images: test-f2.fits
#      IMAGE      NPIX      MEAN      STDEV      MIN      MAX
_      test-f2.fits 2472500  2438.   1349.   542.   65535.
```

Yes it is consistent for frame because if we look from ds9:

```
NAXIS1 =      1150 /
```



NAXIS2 = 2150 /

But not if see the one opened from display:

NAXIS1 = 4096 / Axis Length

NAXIS2 = 4096 / Axis Length

Dimension of actual image was 1024x2045 after inspecting the image in DS9.

5. Display 'photo1.fits'. Examine the profiles of stars at (34, 785), (114,852) and (331,364). Save the radial profiles in the directory you have created. Comment on the shape. Given that the electronics for this camera used a 16-bit Analog to Digital converter, explain why one particular profile looks weird.

As we can see that the radial profile for (34, 785 and (331,364) is fine and matching and thus represent the PSF value of the telescope but that is not the case for (114,852) since as we can see it has reached the saturation limit beyond its linear scale. Hence this is not a good source to observe over this integration time.

