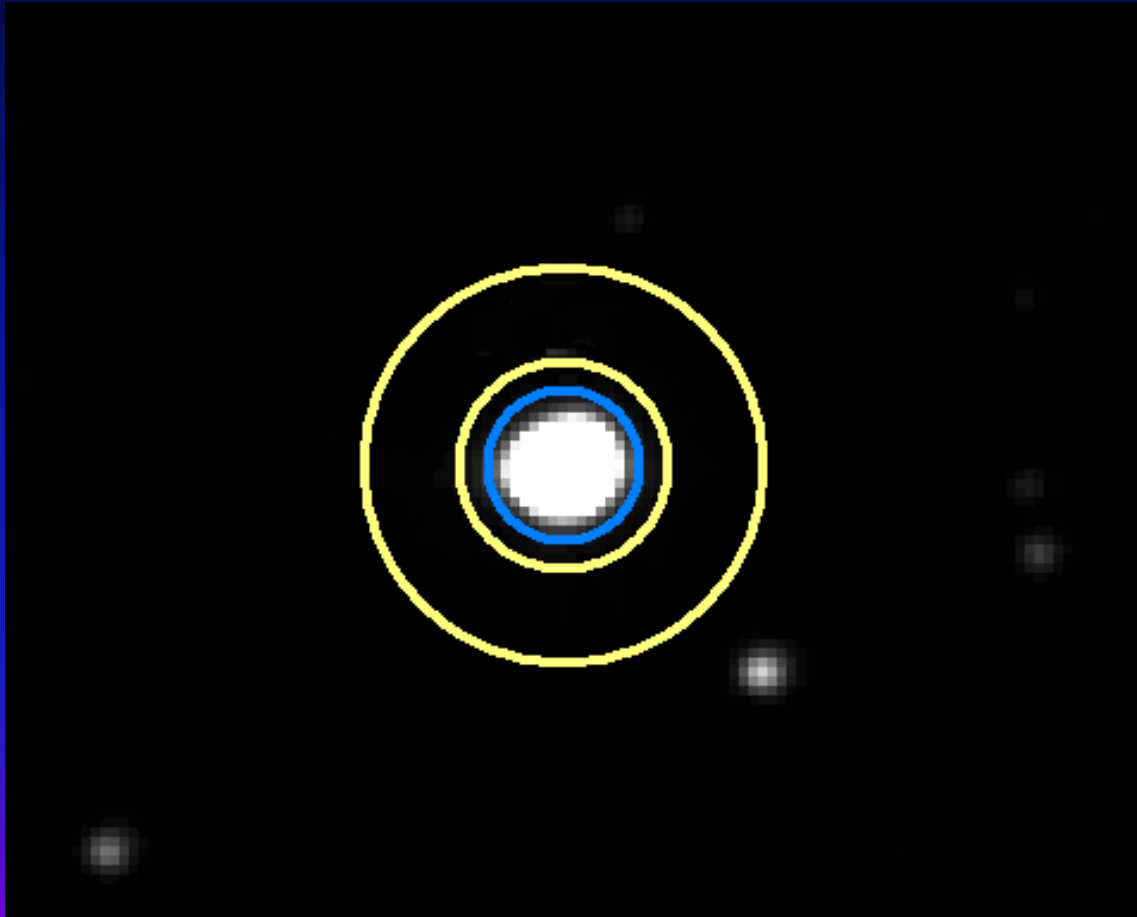


# Photometry

# Aperture Photometry



# Aperture Photometry



Image of open cluster NGC 957

# Aperture Photometry

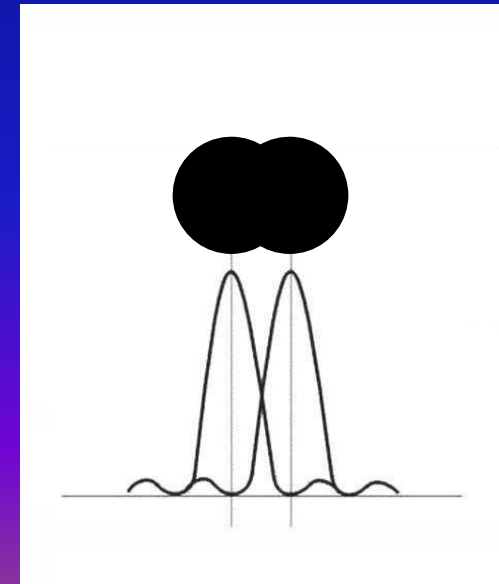
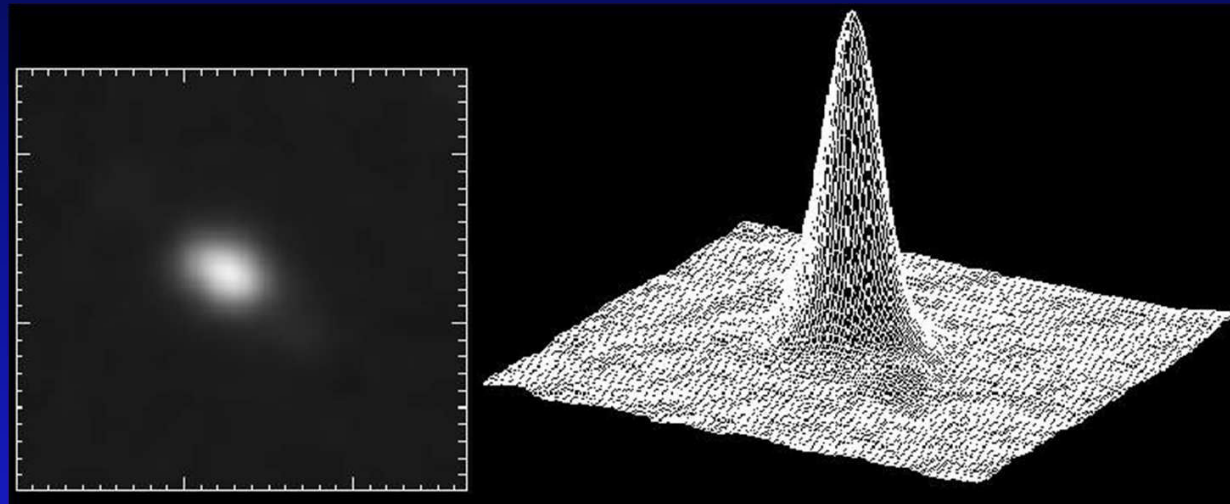


**Crowded Field**

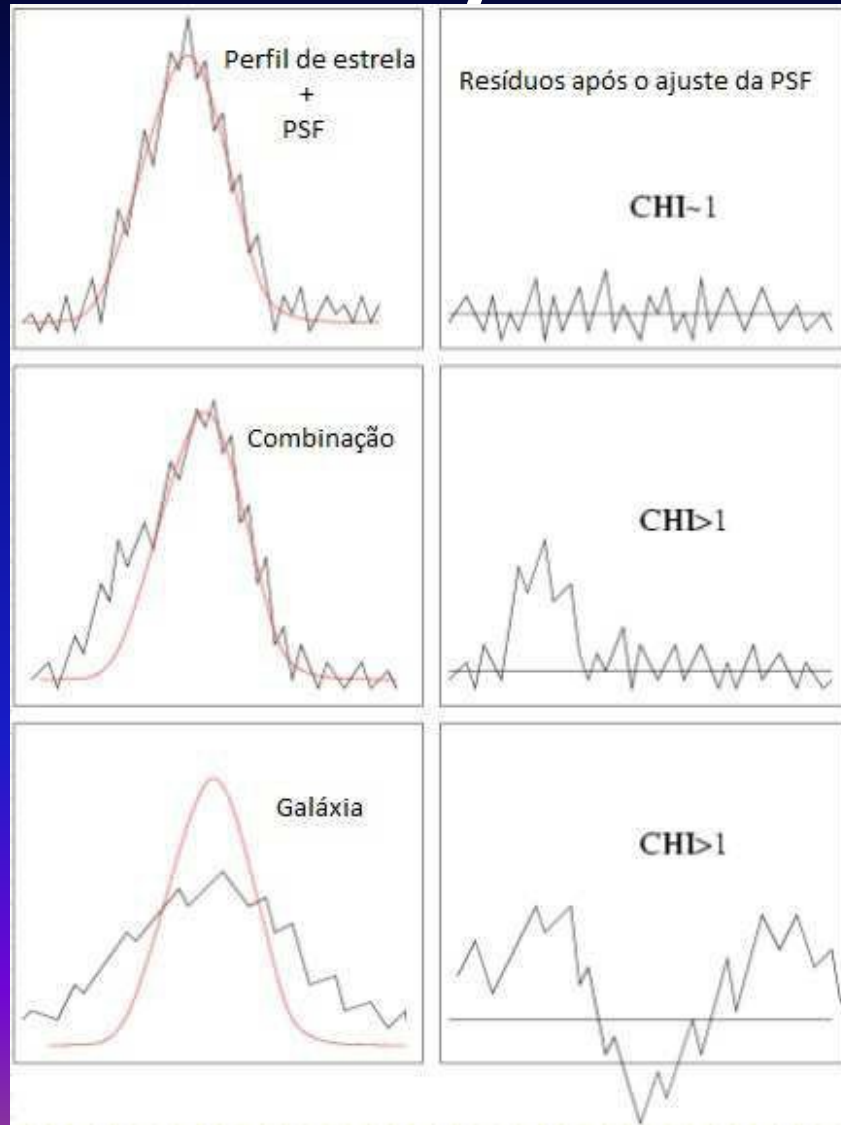
**Source Confusion**

# PSF Photometry :

Point Spread Function(PSF)

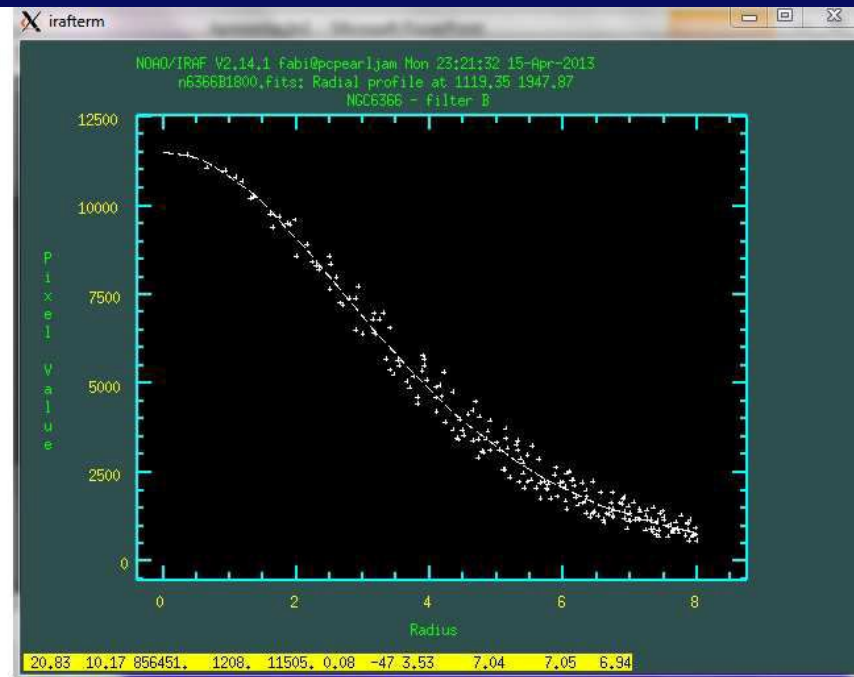
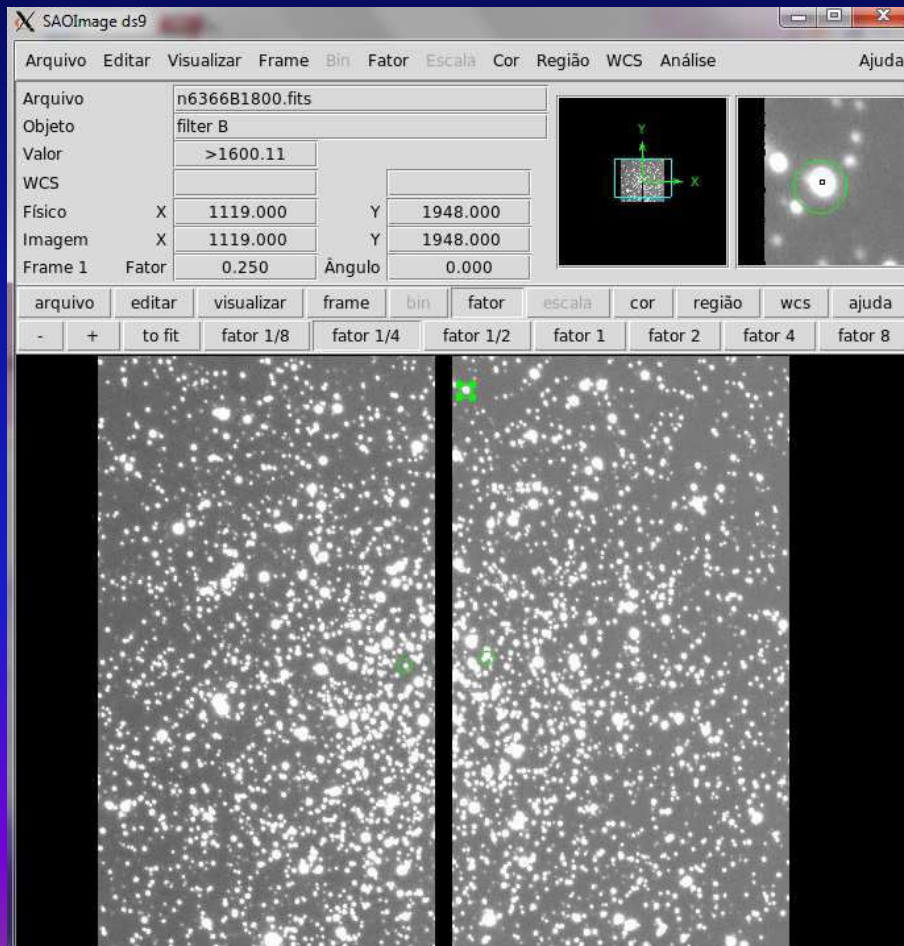


# PSF Photometry:

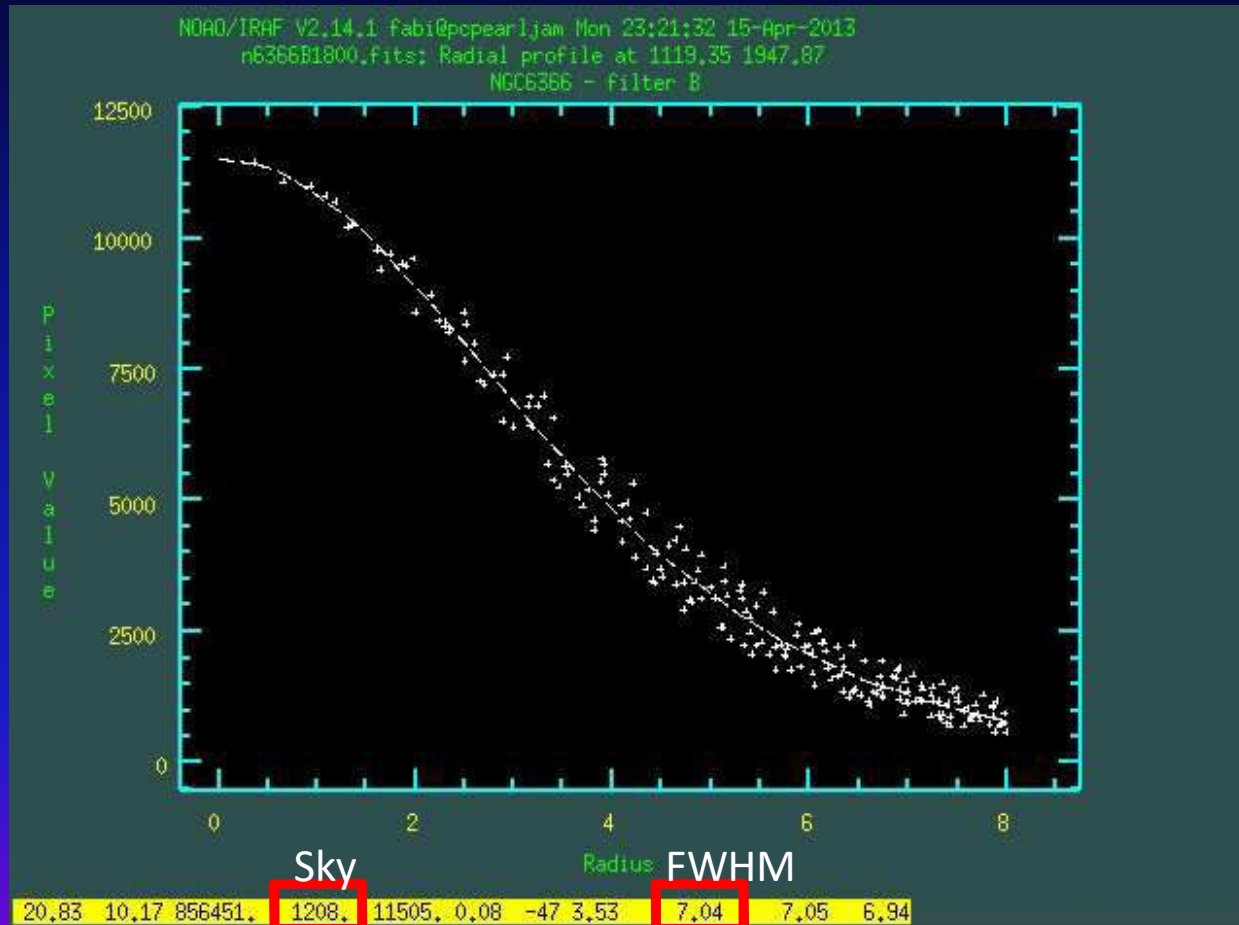


# Photometry using IRAF

Imexamine



# Photometry using IRAF

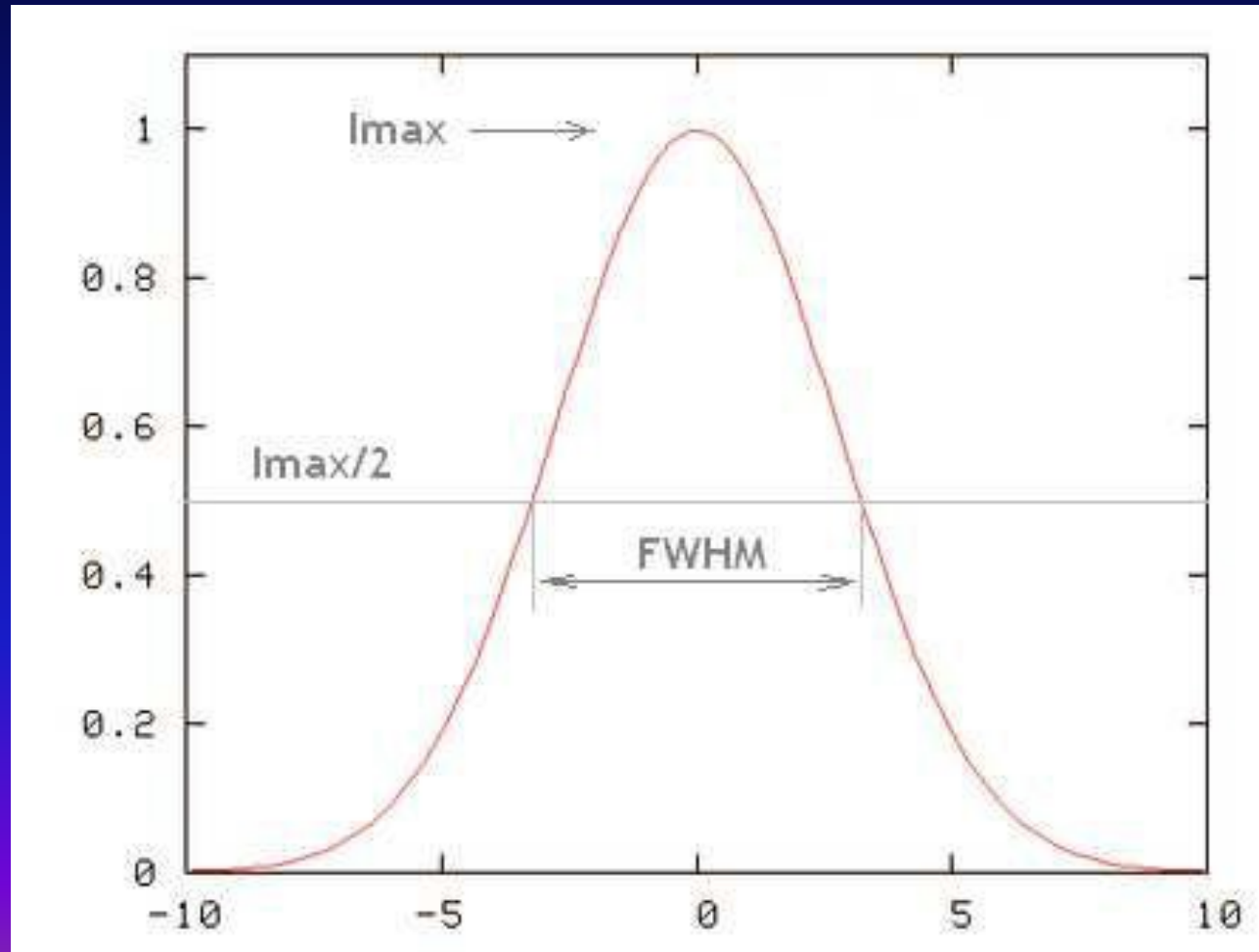


$$= \sqrt{\quad}$$

Annulus=2.5 FWHM (At least)



# Photometry using IRAF



# Photometry using IRAF

```

      IRAF
Image Reduction and Analysis Facility

PACKAGE = daophot
TASK = daofind

image =          Input image(s)
output =        default) Output coordinate file(s) (default: image.coo,?)
(starmap=      ) Output density enhancement image(s)
(skymap =      ) Output sky image(s)
(datapar=     ) Data dependent parameters
(findpar=     ) Object detection parameters
(boundar=     nearest) Boundary extension (constant|nearest|reflect|wra
(constan=     0.) Constant for boundary extension
(interac=     no) Interactive mode ?
(icomman=     ) Image cursor: [x y wcs] key [cmd]
(gocomman=    ) Graphics cursor: [x y wcs] key [cmd]
(wcsout =     )_wcsout) The output coordinate system (logical,tv,physica
(cache =      )_cache) Cache the image pixels ?
(verify =     )_verify) Verify critical daofind parameters ?
(update =     )_update) Update critical daofind parameters ?
(verbose=     )_verbose) Print daofind messages ?
(graphic=    )_graphics) Graphics device
(display=    )_display) Display device
(mode =      ql)

      ESC-? for HELP
```

# Photometry using IRAF

```

                                I R A F
                                Image Reduction and Analysis Facility

PACKAGE = daophot
  TASK = datapars

(scale =          1.) Image scale in units per pixel
(fwhmpsf=        2.5) FWHM of the PSF in scale units
(emissio=        yes) Features are positive ?
(sigma =         0.) Standard deviation of background in counts
(datamin=        INDEF) Minimum good data value
(datamax=        INDEF) Maximum good data value
(noise =         poisson) Noise model
(ccdread=        ) CCD readout noise image header keyword
(gain =          ) CCD gain image header keyword
(readnoi=        0.) CCD readout noise in electrons
(epadu =         1.) Gain in electrons per count
(exposur=        ) Exposure time image header keyword
(airmass=        ) Airmass image header keyword
(filter =        ) Filter image header keyword
(obstime=        ) Time of observation image header keyword
(itime =         1.) Exposure time
(xairmas=        INDEF) Airmass
(ifilter=        INDEF) Filter
(otime =        INDEF) Time of observation
(mode =         ql)

                                ESC-? for HELP
```

# Photometry using IRAF

```
      IRAF
Image Reduction and Analysis Facility

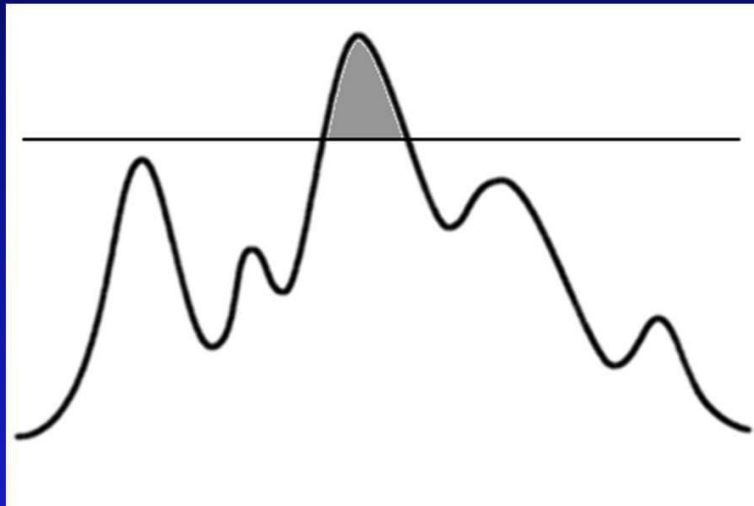
PACKAGE = daophot
  TASK = findpars

(thresho=      4.) Threshold in sigma for feature detection
(nsigma =     1.5) Width of convolution kernel in sigma
(ratio =       1.) Ratio of minor to major axis of Gaussian kernel
(theta =       0.) Position angle of major axis of Gaussian kernel
(sharplo=     0.2) Lower bound on sharpness for feature detection
(sharphi=      1.) Upper bound on sharpness for feature detection
(roundlo=     -1.) Lower bound on roundness for feature detection
(roundhi=       1.) Upper bound on roundness for feature detection
(mkdetec=     no) Mark detections on the image display ?
(mode =       ql)

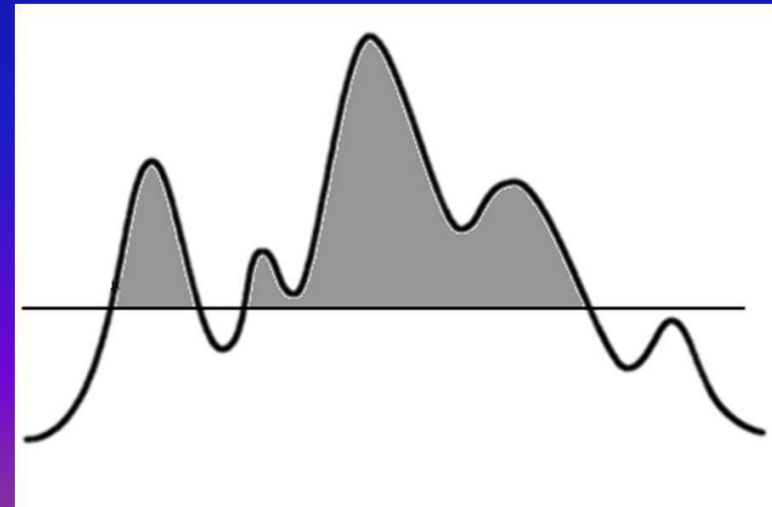
      ESC-? for HELP
```

# Photometry using IRAF

Threshold between 4 and 6



Threshold too high



Threshold too low

# Photometry using IRAF

```

      IRAF
Image Reduction and Analysis Facility

PACKAGE = daophot
  TASK = phot

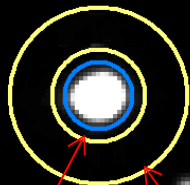
image =          Input image(s)
coords =        default Input coordinate list(s) (default: image,coo,?)
output =        default Output photometry file(s) (default: image,mag,?)
skyfile =       Input sky value file(s)
(plotfil=      ) Output plot metacode file
(datapar=      ) Data dependent parameters
(centerp=      ) Centering parameters
(fitskyp=      ) Sky fitting parameters
(photpar=      ) Photometry parameters
(interac=      no) Interactive mode ?
(radplot=      no) Plot the radial profiles?
(icomman=      ) Image cursor: [x y wcs] key [cmd]
(gcomman=      ) Graphics cursor: [x y wcs] key [cmd]
(wcsin =       )_wcsin) The input coordinate system (logical,tv,physical
(wcsout =      )_wcsout) The output coordinate system (logical,tv,physica
(cache =       )_cache) Cache the input image pixels in memory ?
(verify =     )_verify) Verify critical phot parameters ?
(update =     )_update) Update critical phot parameters ?
(verbose =    )_verbose) Print phot messages ?
(graphic =   )_graphics) Graphics device
(display =   )_display) Display device
(mode =      ql)

      ESC-? for HELP
```

# Photometry using IRAF

```
IRAF
Image Reduction and Analysis Facility
PACKAGE = daophot
TASK = fitskypars

(salgori= mode) Sky fitting algorithm
(annulus= 10.) Inner radius of sky annulus in scale units
(dannulu= 10.) Width of sky annulus in scale units
(skyvalu= 2.) User sky value
(smaxite= 10) Maximum number of sky fitting iterations
(sloclip= 0.) Lower clipping factor in percent
(shiclip= 0.) Upper clipping factor in percent
(snrejec= 50) Maximum number of sky fitting rejection iteratio
(sloreje= 3.) Lower K-sigma rejection limit in sky sigma
(shireje= 3.) Upper K-sigma rejection limit in sky sigma
(khist = 3.) Half width of histogram in sky sigma
(binsize= 0.1) Binsize of histogram in sky sigma
(smooth = no) Boxcar smooth the histogram
(rgrow = 0.) Region growing radius in scale units
(mksky = no) Mark sky annuli on the display
(mode = ql)
```



annulus

dannulus

ESC-? for HELP

# Photometry using IRAF

```
IRAF
Image Reduction and Analysis Facility
PACKAGE = daophot
TASK = photpars

(weighti=      constant) Photometric weighting scheme
(apertur=      9) List of aperture radii in scale units
(zmag =       25.) Zero point of magnitude scale
(mkapert=     yes) Draw apertures on the display
(mode =       q1)
```



Aperture

ESC-? for HELP



# PSF photometry with IRAF

Select the PSF candidates

- \* Relative isolated stars
- \* Unsaturated stars
- \* Stars spread through the CCD
- \* 25 to 30 candidates!

# PSF photometry with IRAF

```

      IRAF
      Image Reduction and Analysis Facility
PACKAGE = daophot
      TASK = pstselect

image =  Image for which to build psf star list
photfile= default Photometry file (default: image,mag,?)
pstfile = default Output psf star list file (default: image,pst,?)
maxnpsf = 25 Maximum number of psf stars
(mkstars= no) Mark deleted and accepted psf stars
(plotfil= ) Output plot metacode file
(datapar= ) Data dependent parameters
(daopars= ) Psf fitting parameters
(interac= no) Select psf stars interactively ?
(plottyp= mesh) Default plot type (mesh|contour|radial)
(icomman= ) Image cursor: [x y wcs] key [cmd]
(gcomman= ) Graphics cursor: [x y wcs] key [cmd]
(wcsin = )_wcsin) The input coordinate system (logical,tv,physical)
(wcsout = )_wcsout) The output coordinate system (logical,tv,physical)
(cache = )_cache) Cache the input image pixels in memory ?
(verify = )_verify) Verify critical pstselect parameters?
(update = )_update) Update critical pstselect parameters?
(verbose= )_verbose) Print pstselect messages?
(graphic= )_graphics) Graphics device
(display= )_display) Image display device
(mode = ql)

      ESC-? for HELP
```

# PSF photometry with IRAF

The image displays two windows from the IRAF software suite. The left window, titled 'irafterm', shows a 3D surface plot of a Point Spread Function (PSF) for the object NGC 6366. The plot is a wireframe mesh with a central peak, showing the distribution of light in three dimensions. The axes are labeled with coordinates: X (1304), Y (1324), and Z (1304). The right window, titled 'SAOImage ds9', shows the main interface for image analysis. It includes a menu bar (Arquivo, Editar, Visualizar, Frame, Bin, Fator, Escala, Cor, Região, WCS, Análise, Ajuda) and a toolbar with buttons for file operations and zooming. The main display area shows a grayscale image of a star field with several stars highlighted by pink circles. A green box highlights a specific star, and a green crosshair indicates its position. The interface also includes a control panel for the selected object, showing parameters like 'Fator' (0.500) and 'Ângulo' (0.000). Below the main display, there is a list of parameters and their values, and a warning message: 'Warning: setting CD2\_2 to 1.'

irafterm

NOAO/IRAF V2.14.1 Fabi@pcpearljam Tue 01:48:52 16-Apr-2013  
n6366B1200.fits: Surface plot of [723:743,1304:1324]  
NGC6366

SAOImage ds9

Arquivo Editar Visualizar Frame Bin Fator Escala Cor Região WCS Análise Ajuda

Arquivo n6366B1200.fits  
Objeto NGC6366  
Valor  
WCS  
Físico X Y  
Imagem X Y  
Frame 1 Fator 0.500 Ângulo 0.000

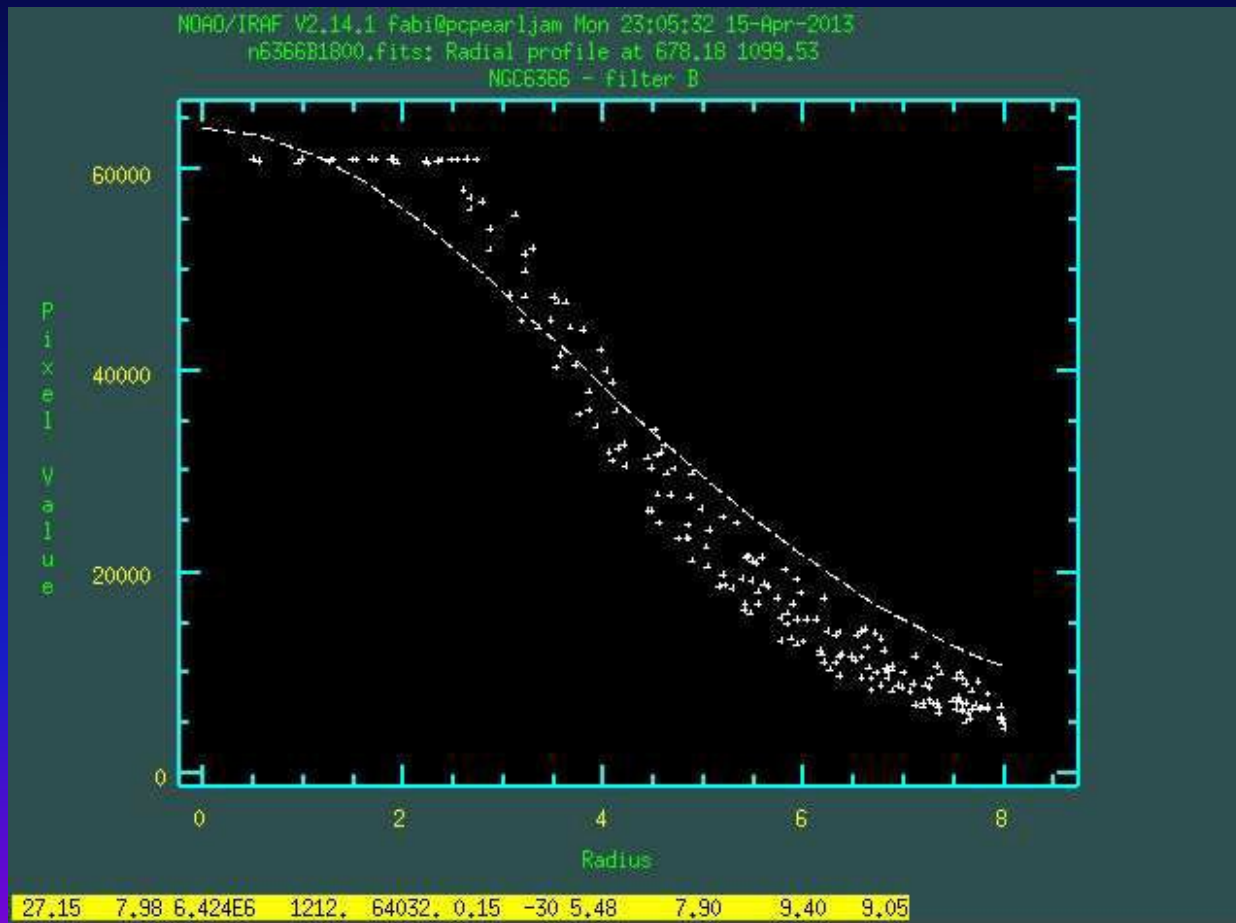
arquivo editar visualizar frame bin fator escala cor região wcs ajuda

- + to fit fator 1/8 fator 1/4 fator 1/2 fator 1 fator 2 fator 4 fator 8

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

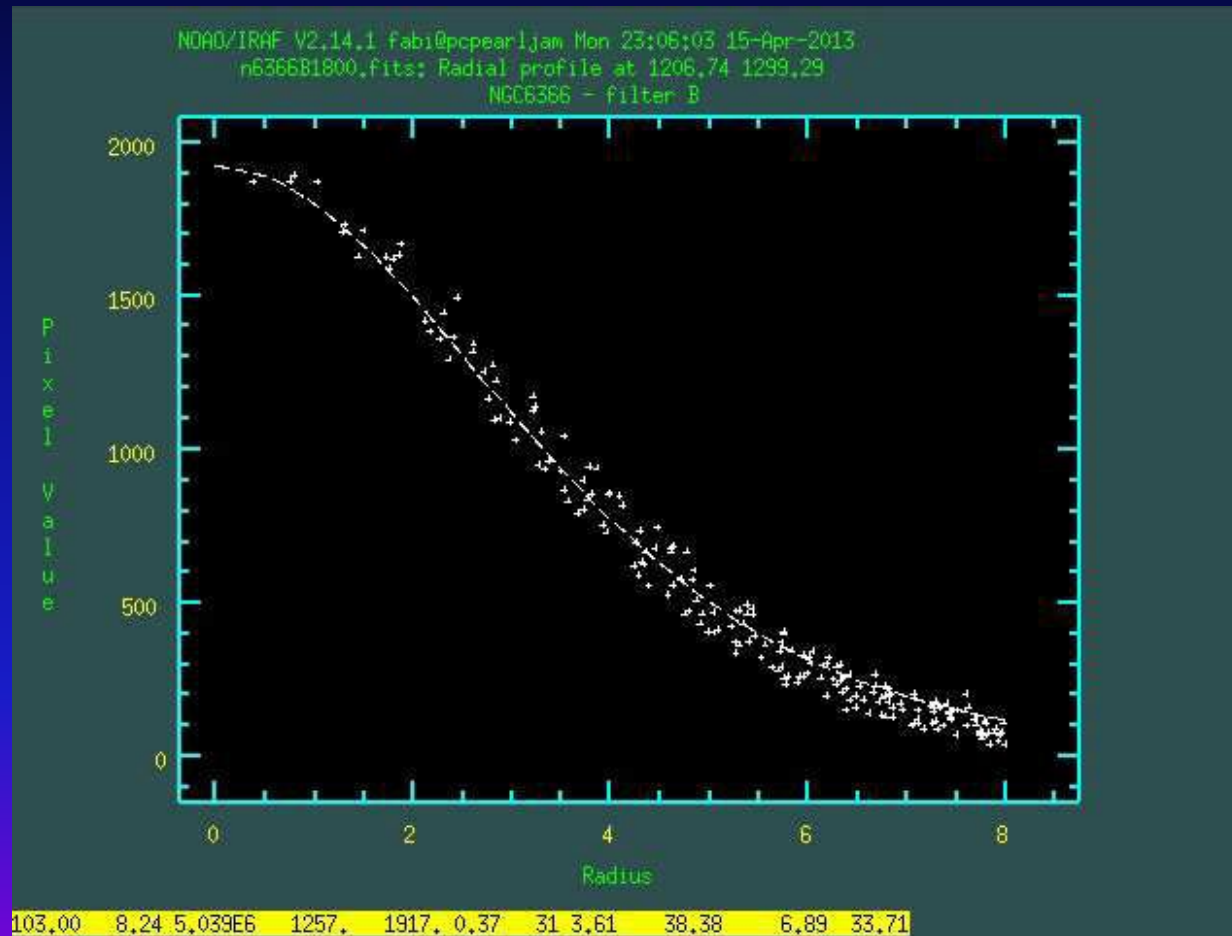
Warning: setting CD2\_2 to 1.

# PSF photometry with IRAF



Estrela saturada

# PSF photometry with IRAF



Unsaturated star

# PSF photometry with IRAF

```

                                I R A F
                                Image Reduction and Analysis Facility

PACKAGE = daophot
TASK = psf

image =  Input image(s) for which to build PSF
photfile= default Input photometry file(s) (default: image.mag,?)
pstfile = Input psf star list(s) (default: image.pst,?)
psfimage= default Output PSF image(s) (default: image.psf,?)
opstfile= default Output PSF star list(s) (default: image.pst,?)
groupfil= default Output PSF star group file(s) (default: image.psg,?)
(plotfil= ) Output plot metacode file
(datapar= ) Data dependent parameters
(daopars= ) Psf fitting parameters
(matchby= yes) Match psf star list to photometry file(s) by id number ?
(interac= yes) Compute the psf interactively ?
(mkstars= no) Mark deleted and accepted psf stars ?
(showplo= yes) Show plots of PSF stars ?
(plottyp= mesh) Default plot type (mesh|contour|radial)
(icomman= ) Image cursor: [x y wcs] key [cmd]
(gcomman= ) Graphics cursor: [x y wcs] key [cmd]
(wcsin = )_,wcsin) The input coordinate system (logical,tv,physical,world)
(wcsout = )_,wcsout) The output coordinate system (logical,tv,physical)
(cache = )_,cache) Cache the input image pixels in memory ?
(verify = )_,verify) Verify critical psf parameters ?
(update = )_,update) Update critical psf parameters ?
(verbose= )_,verbose) Print psf messages ?
More
ESC-? for HELP
```

# PSF photometry with IRAF

```

                                I R A F
                                Image Reduction and Analysis Facility

PACKAGE = daophot
TASK = daopars

(funcio= auto) Form of analytic component of psf model
(varorde= 0) Order of empirical component of psf model
(nclean = 0) Number of cleaning iterations for computing psf model
(saturat= no) Use wings of saturated stars in psf model computation ?
(matchra= 3.) Object matching radius in scale units
(psfrad = 11.) Radius of psf model in scale units
(fitrad = 3.) Fitting radius in scale units
(recente= yes) Recenter stars during fit ?
(fitsky = no) Recompute group sky value during fit ?
(groupsk= yes) Use group rather than individual sky values ?
(sannulu= 0.) Inner radius of sky fitting annulus in scale units
(wsannul= 11.) Width of sky fitting annulus in scale units
(flaterr= 0.75) Flat field error in percent
(proferr= 5.) Profile error in percent
(maxiter= 50) Maximum number of fitting iterations
(clipexp= 6) Bad data clipping exponent
(clipran= 2.5) Bad data clipping range in sigma
(mergera= INDEF) Critical object merging radius in scale units
(critsnr= 1.) Critical S/N ratio for group membership
(maxnsta= 10000) Maximum number of stars to fit
(maxgrou= 60) Maximum number of stars to fit per group
(mode = ql)

                                ESC-? for HELP
```

# PSF photometry with IRAF

fitrad= circular area in which the pixels will be used to calculate the PSF fitting. Usually the FWHM can be used, unless there are too much crowding.

Psfrad= radio in which the PSF is defined. Must be larger than the radius of the brightest star you want to measure.



# PSF photometry with IRAF

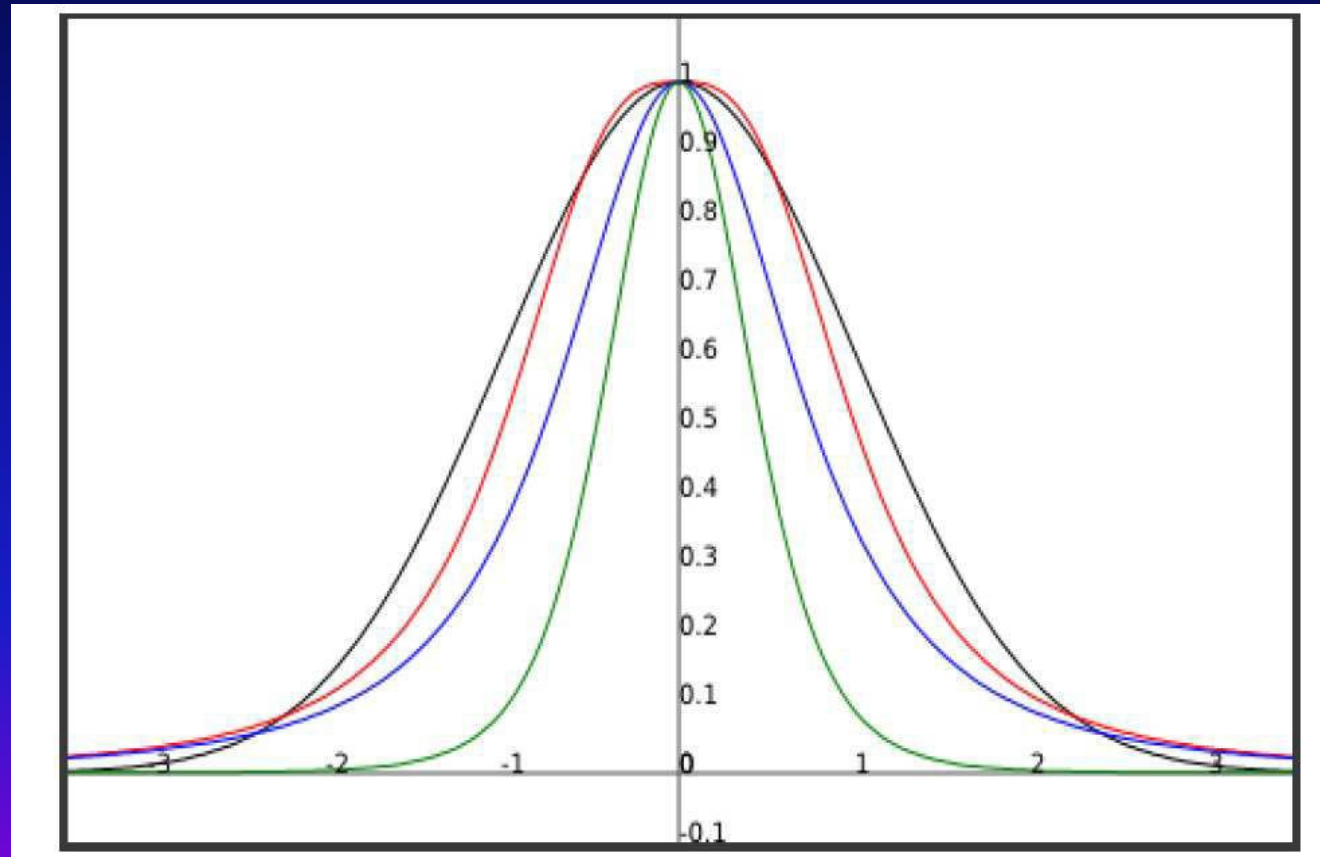
## Function

gaussian (black)  
lorentzia (red) Moffat  
 $b=1.5$  (blue) Moffat  
 $b=3.5$  (green)

$$G(r) \propto \exp\left(-\frac{r^2}{2a^2}\right)$$

$$L(r) \propto \frac{1}{1 + (r^2/a^2)^b}$$

$$M(r) \propto \frac{1}{(1 + r^2/a^2)^b}$$



$r$  is the distance to the center of the object.  $a$  and  $b$  are the fitting parameters

# PSF photometry with IRAF

## Some commands of PSF task

a= add star to the psf candidates list

f= fits PSF

d= delete star from the PSF list

l = list the PSF candidates

w= write the PSF to file


# PSF photometry with IRAF

SAOImage ds9

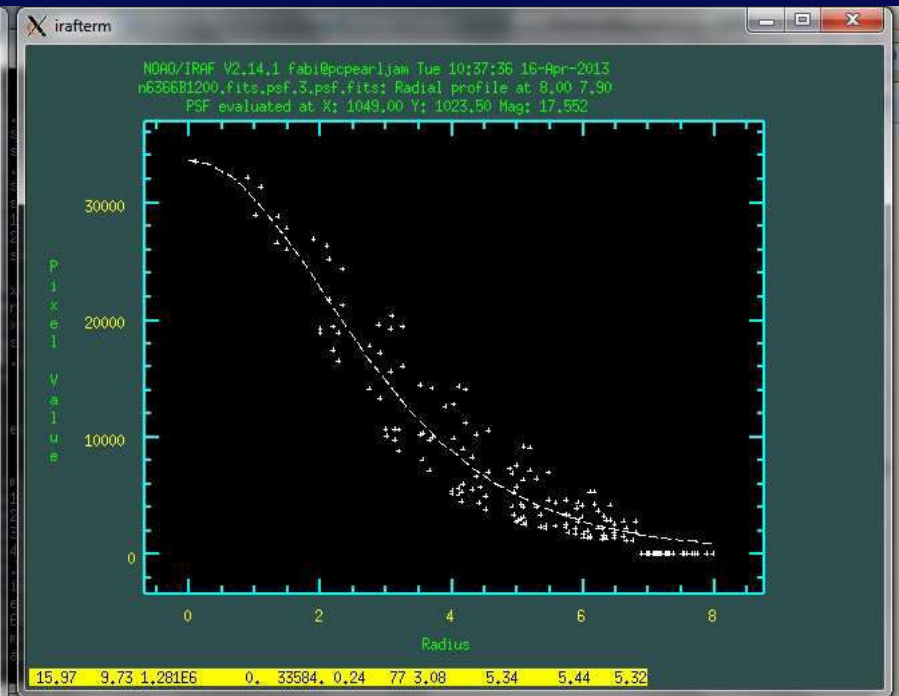
Arquivo Editar Visualizar Frame Bin Fator Escala Cor Região WCS Análise Ajuda

Arquivo: n6366B1200.fits.psf.3.psf.fits  
Objeto: PSF evaluated at X: 1049.00 Y: 1023.50 Mag:  
Valor:  
WCS:  
Físico X Y  
Imagem X Y  
Frame 1 Fator 2.000 Ângulo 0.000

arquivo editar visualizar frame bin fator escala cor região wcs ajuda  
- + to fit fator 1/8 fator 1/4 fator 1/2 fator 1 fator 2 fator 4 fator 8



task = seepsf



# PSF photometry with IRAF

```

                                I R A F
                                Image Reduction and Analysis Facility

PACKAGE = daophot
TASK = allstar

image = █ Image corresponding to photometry
photfile= default Input photometry file (default: image.mag.?)
psfimage= default PSF image (default: image.psf.?)
allstarf= default Output photometry file (default: image.als.?)
rejfile = default Output rejections file (default: image.arj.?)
subimage= default Subtracted image (default: image.sub.?)
(datapar= ) Data dependent parameters
(daopars= ) Psf fitting parameters
(wcsin = )_wcsin) The input coordinate system (logical,tv,physical,world)
(wcsout = )_wcsout) The output coordinate system (logical,tv,physical)
(wcspsf = )_wcspsf) The psf coordinate system (logical,tv,physical)
(cache = yes) Cache the data in memory?
(verify = )_verify) Verify critical allstar parameters?
(update = )_update) Update critical allstar parameters?
(verbose= )_verbose) Print allstar messages?
(version= 2) Version
(mode = ql)

ESC-? for HELP
```

# PSF photometry with IRAF

## Output from ALLSTAR

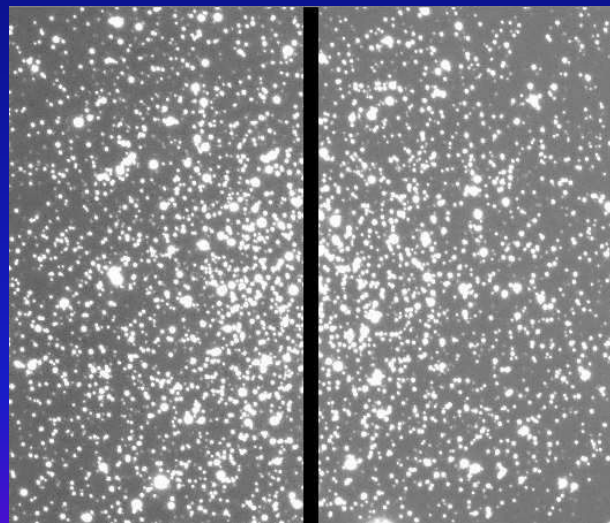
- Photometry list
- Rejected list
- Subtracted image

# PSF photometry with IRAF

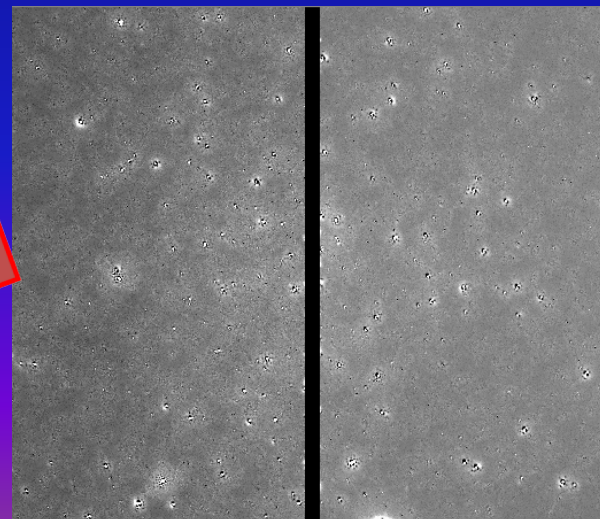
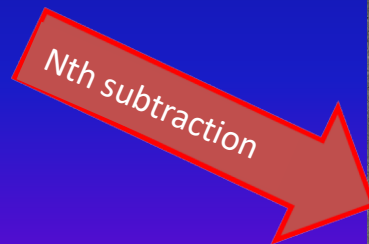
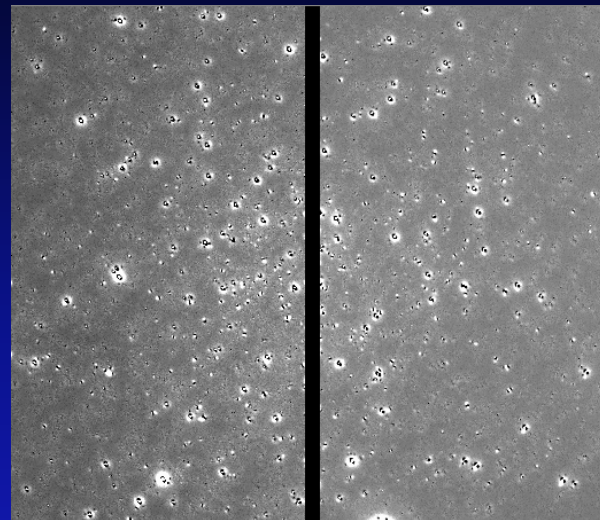
1. Find stars in the subtracted image
2. Concatenate files from FIND from original and subtracted (PCONCAT)
3. Rename the resulting file (PRENUMBER)
4. Re-do the aperture photometry with this new list
5. Re-do the PSF photometry with the new list



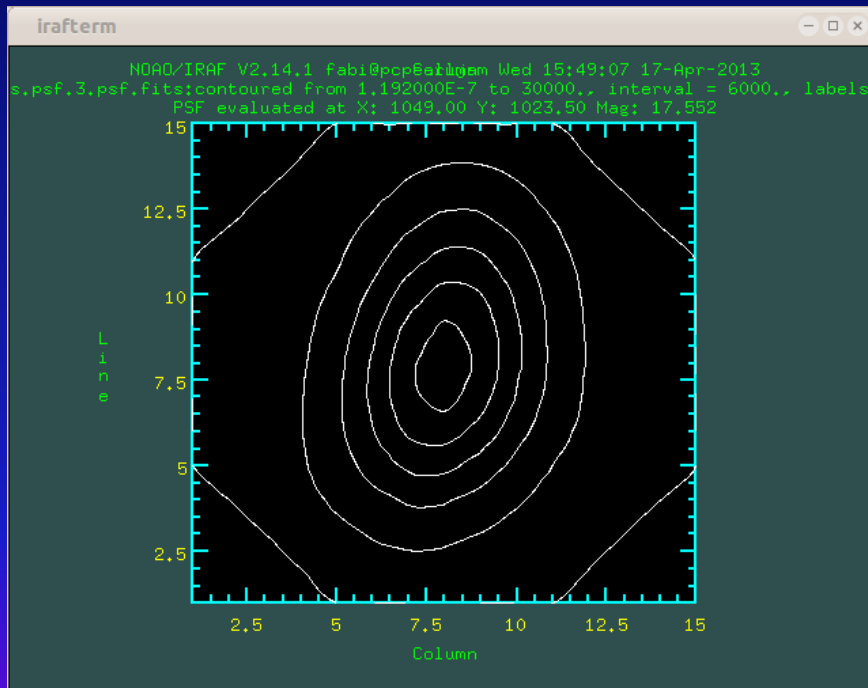
# PSF photometry with IRAF



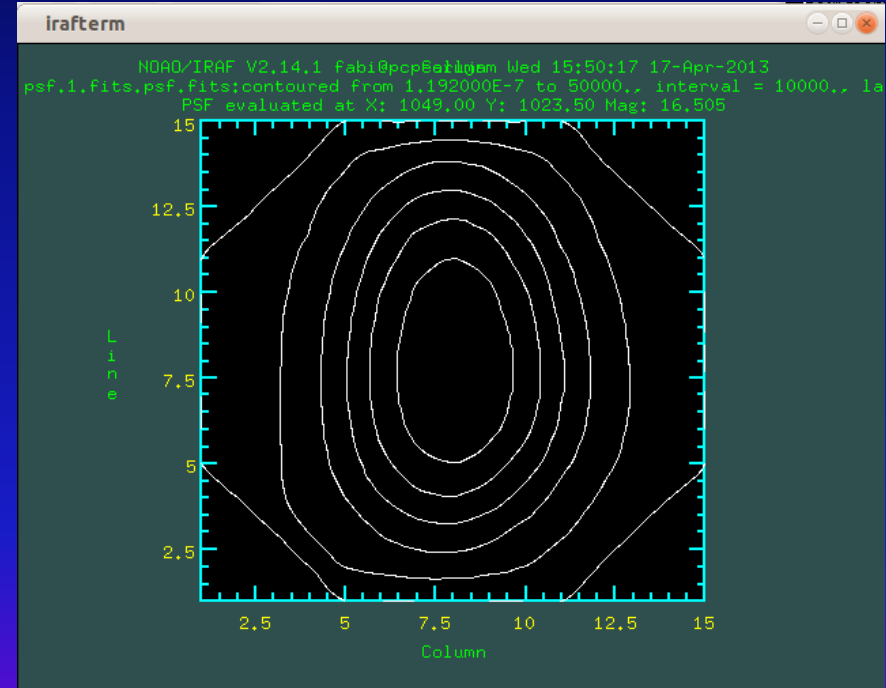
Original Image



# PSF photometry with IRAF



B



V



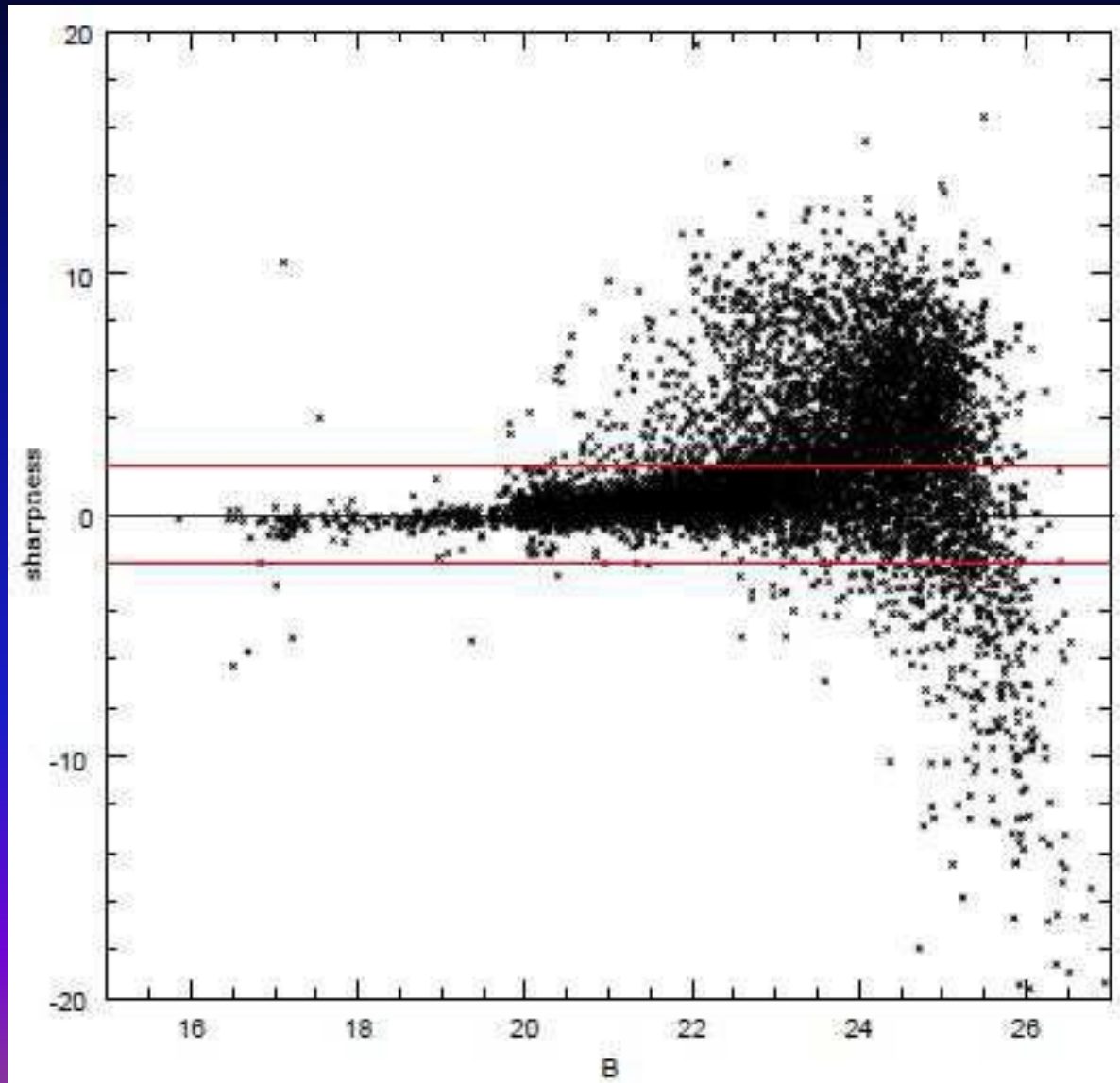
# Sharpness

Isolated Star } Sharpness próximo à zero

Semi-resolved Galaxies  
Double or mixed sources } Sharpness  $\gg$  zero

Cosmic rays  
and  
Image defects } Sharpness  $\ll$  zero

# Sharpness



# Diagrama cor magnitude

IRAF

```
cl>pdump id,xcenter,ycenter,mag,merr,sharp
```

terminal

```
>sort 1,1b arquivo1
```

```
>sort 1,1b arquivo2
```

```
>join arquivo1 arquivo2
```

# Color-magnitude Diagram

